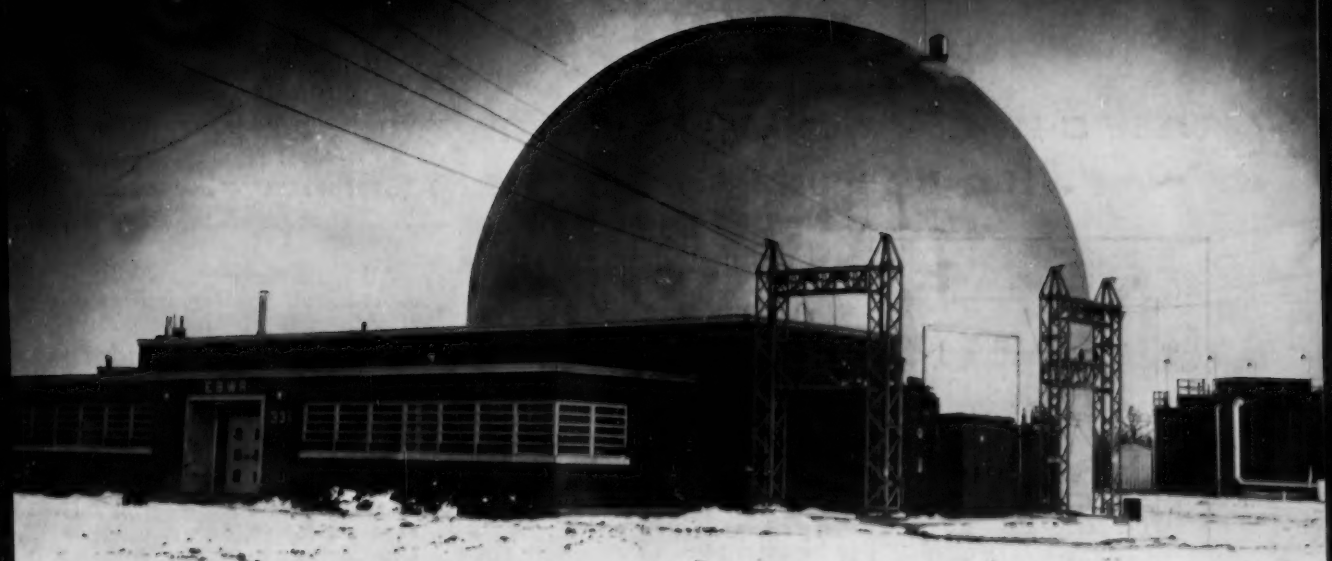
ELECTRICAL ENGINEERING

OCTOBER 1957



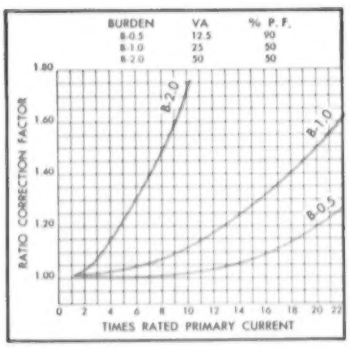
FINE PARTICLE MAGNETS

ORDERLY CREATIVE INVENTING

ECONOMIC IMPLICATIONS OF AUTOMATION

NEW 5-Kv Molded CURRENT TRANSFORMER

...for Indicating and Tripping Service



Typical 60-cycle overcurrent curves for Type LRM current transformer.

Extends Line of Maintenance-free Epoxy-resin Units

Latest in a growing family of molded units, this Type LRM current transformer rated 5 kv is already a prime favorite with panel and switchgear designers. Molded of epoxy resin, this new transformer is virtually maintenance-free. It has high impact strength . . . resists mechanical forces, moisture and fire. These advantages at no extra cost.

All units are supplied with a short-circuiting strap, removable after installation. Base design permits mounting anywhere—on walls, bars, channels, etc.

Allis-Chalmers instrument transformers are available in the widest possible rating range. Many are molded units. Other epoxy-resin designs are in pilot production. For complete information, see your A-C representative, or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

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A-5503

ELECTRICAL ENGINEERING

OCTOBER 1957
Vol. 76, No. 10

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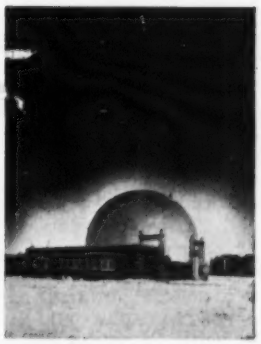

THE COVER: The Experimental Boiling Water Reactor put "on-stream" a few months ago at the Argonne National Laboratories where scientists have been engaged in research on atomic energy, chemistry, physics, biology, medicine, and other fields. Story on page 898.

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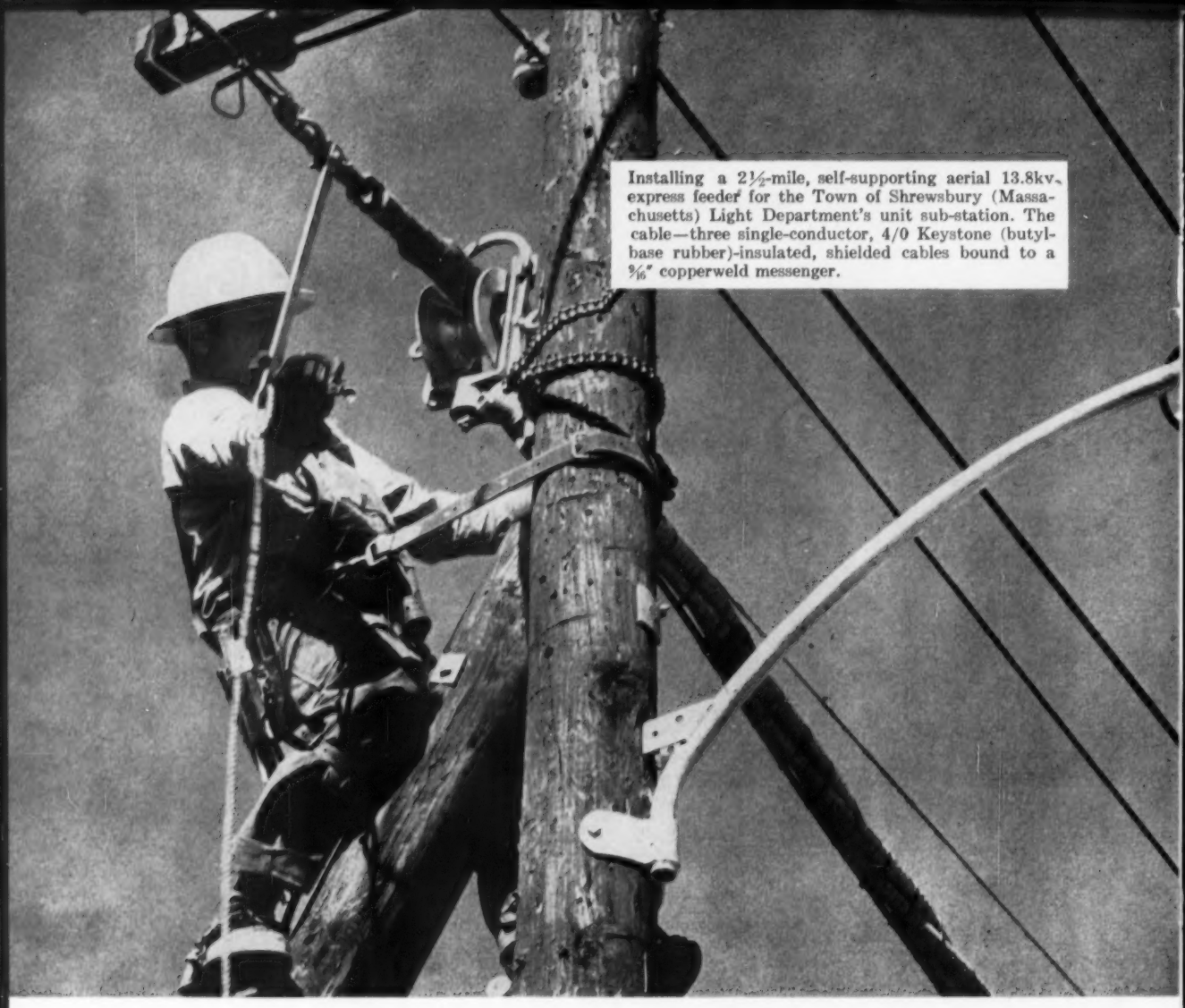

Installing a 2½-mile, self-supporting aerial 13.8kv. express feeder for the Town of Shrewsbury (Massachusetts) Light Department's unit sub-station. The cable—three single-conductor, 4/0 Keystone (butyl-base rubber)-insulated, shielded cables bound to a 5/16" copperweld messenger.

Contractor: The Theodore D. Bross Line Construction Company

Modernize with Okonite self-supporting aerial cable...

The Town of Shrewsbury Light Department did just this when they recently installed a 13.8kv express feeder. They chose an Okonite self-supporting aerial cable because they wanted a superior installation that would practically eliminate tree trimming costs . . . be more reliable in storms (operate even with poles down) . . . reduce pole congestion . . . assure fewer interruptions or outages . . . have a moderate cost . . . provide improved voltage regulation because of lower reactance . . . and be more economical to operate and maintain than equivalent open wire lines.

In choosing Keystone (butyl-base rubber)-insulated cables for this important feeder, Shrewsbury Light Department was also banking on high voltage cable with a record for long and dependable service . . . high resistance to ozone and corona cutting . . . ability to take sharp bends . . . stable operation at copper conductor temperatures as high as 85C at 15kv . . . excellent resistance to moisture and extremes of temperatures.

For the complete story on Keystone-insulated cables, contact your Okonite representative . . . or write for Bulletin EG-463 where the results of field service and tests are reported with graphs and charts together with 36 pages of technical data.

The Okonite Company, Passaic, New Jersey.

where there's electrical power . . . there's **OKONITE CABLE**

4912

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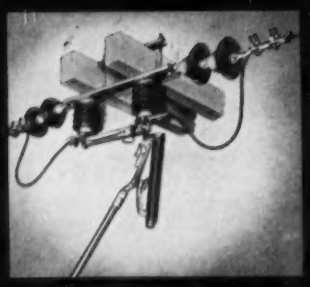
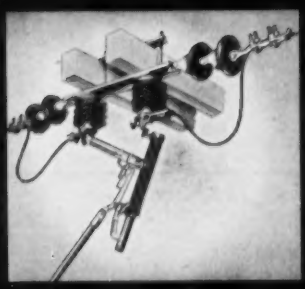
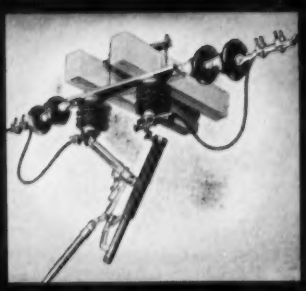
NOW! low-cost load switching for your entire distribution system... just hook Loadbuster® across this new S&C Tool Operated Disconnect



Loadbuster is hooked to attachment hook of disconnect



Loadbuster is pulled downward, opening disconnect blade



Loadbuster interrupts circuit and latches open

Loadbuster freed from attachment hook; to be twisted from pull ring

That's right! Now you can make load switching universal. At the same time you get the rugged reliability you'd expect from a station-type disconnect, while paying no more than you would for distribution-type disconnects.

This new S&C Tool Operated Disconnect switches loads dependably with Loadbuster, S&C's portable loadbreak tool, and it is the only distribution disconnect with published short-time ratings and published insulation values.

Why is this published data important? Just take a look at what has been happening on distribution lines in the past few years—

Today's Disconnect Problem

Performance requirements for disconnects have risen rapidly as a result of higher voltages, 400-ampere loads, and alarming increases in available short-circuit currents. This type of duty might suggest the use of 600-ampere, station-type equipment, but distribution system budgets can't stand the cost.

Yet the job is too heavy for the ordinary distribution disconnect which has inadequate short-time capability, substandard insulation characteristics, insubstantial construction, no load switching potentiality, and extremely limited repetitive capability.

Up until now there has been no device to fill the void—no disconnect suited to a modern, high-reliability, distribution system, yet matching distribution economics. To meet this need, S&C is introducing this Tool Operated Disconnect. It meets the rigorous requirements conventionally filled by group-operated disconnects, hook-operated, station-type disconnects, and conventional load interrupters.

. . . and Load Switching Needs

Load switching is a serious problem today. Primary distribution voltages of 12-14 kv, currents of 100 to 400 amperes, and the associated charging and magnetizing currents cannot be switched without establishing persistent, spreading arcs.

Until recently, the only dependable solution to load switching needs has been the load interrupter, whose cost can only be justified at substations, subtransmission sectionalizing points, and at key sectionalizing points. Now with this new disconnect you can have universal load switching—economically—using Loadbuster.

Portability the Key

The key to the Loadbuster system of load switching lies in portability —bringing the interrupting device to a matched disconnect or cutout only when load switching is desired. The cost of Loadbusters is spread over all the disconnects and cutouts in a distribution system.

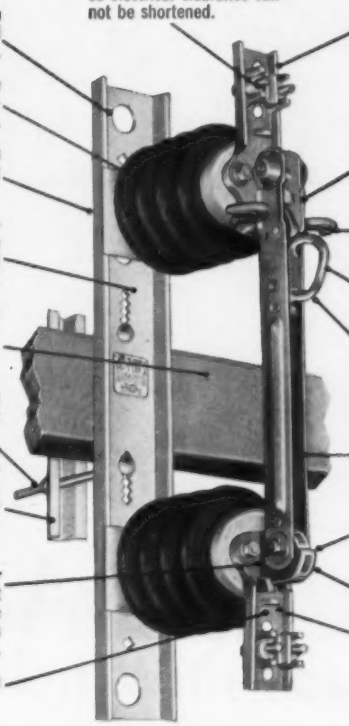
Today you can solve the disconnect problem for your system with S&C's Tool Operated Disconnect . . . a distribution device that doubles for station-type equipment. And since this Tool Operated Disconnect is matched to Loadbuster, load switching comes free! Write for full information.

How Loadbuster Works

Attached to a universal pole, Loadbuster is simply hung on the attachment hook of the Tool Operated Disconnect, and the pull ring hook inserted in the pull ring. As the pole is pulled downward, the disconnect is opened, but a current path is retained through Loadbuster. As the movement continues downward, Loadbuster trips, breaking the circuit positively. It's that easy! There's no arc, no contact burning, and no danger to the lineman operator.

Designed to withstand usage over a long time without maintenance, Loadbuster is operable at any distribution system voltage through 14,400 volts, and can break all load currents through 400 amperes, as well as associated magnetizing and line charging currents; it can also switch all pole top capacitor banks.

the new S&C Tool Operated Disconnect



Connector Bolts can be inserted in one direction only so electrical clearance cannot be shortened.

Dead-Ending Provision base has holes in each end for dead-ending conductors.

Post Insulators provide large leakage distance between live parts and base.

Husky Channel Base gives flat bearing surface against crossarm.

Versatile Mounting Provisions for single and double crossarm, also structure; all needed hardware included.

10½" Metal-to-Metal Open Gap Distance is unusually long for distribution disconnects.

Mounting Bolts extend away from blade, protect clearances to live parts.

Rigid Back-Up Members permit secure draw-up. Bolts insertable only in one direction as shown to maintain electrical clearance.

Double-Stud Insulator Mount insures against shifting or turning of live parts, particularly when closing blade from the side.

Current Path virtually a straight line.

Dual-Purpose Connectors tinned to take aluminum or copper. Large area, reversible clamp accommodates wide range of conductors—up to 450 Mcm copper and 336 Mcm ACSR.

Silver-to-Silver Contacts backed up by stainless steel contact pressure springs.

Attachment Hook for Use with Loadbuster also serves as blade guide.

Positive Latch and Pry-out operates freely from all angles of approach.

Pull Ring Position gives compact construction—with minimum clearance requirements for open blade.

Heavy, Embossed Blades insure positive alignment when closing in.

Machined Contact Surfaces for best possible contact.

Positive 90° Blade Stop

Cable Stop prevents cable end from interfering with disconnect blade action.

Only Distribution Disconnect with Published Performance Data

The performance built into this disconnect (see below) is unmatched in the field of distribution disconnects . . . and the S&C Tool Operated Disconnect costs no more. Plus cost-free load switching! Designed for use with Loadbuster®, this disconnect is, when required, a load interrupter for currents up to 400 amperes.

That this disconnect will give years of maintenance-free, urban or rural service is clear from the construction details shown at the left.

The new disconnect comes complete with all necessary hardware for both single or double crossarm mounting (vertical or inverted), for use with both aluminum and copper conductors. There is nothing extra to buy or to specify.

15 kv—400 amp

Style	Rating						Insulator Characteristics			
	Kv			Amperes			Inches		Withstand Test Voltage kv (Min), 60-cycle	
	Nominal	Max Design	Impulse Withstand (BIL)	Continuous	Short Time Momentary	Short Time 4 sec	Leakage Distance	Dry Arcing Distance	Dry, 1 min	Wet, 10 sec
Branch Feeder	15	15	95	400	20000	12500	13-3/4	6	50	42
Main Feeder	15	15.5	110	400	20000	12500	17	7-1/4	50	45
Station Pin Insulator	15	15.5	110	400	20000	12500	12	7-1/4	50	45
Station Post Insulator	15	15.5	110	400	20000	12500	15-1/2	7-1/4	50	45

Specialists in High-Voltage Circuit Interruption Since 1910

S&C ELECTRIC COMPANY

POWER FUSES • DISTRIBUTION CUTOUTS AND FUSE LINKS • LOAD INTERRUPTERS • METALCLAD SWITCHGEAR

4427 RAVENSWOOD AVENUE • CHICAGO 40, ILLINOIS, U. S. A.

In Canada: S&C Electric Canada, Ltd., 8 Vansco Road, Toronto 14, Ontario

When choosing a premium power cable . . .

How much choice do you <u>really</u> have?

Cable may *look* alike—but you can find many differences in jackets and insulating compounds. And you want only the *best* cable for your operating conditions.

That's why it's important to choose your cable from a manufacturer who offers you a real choice of modern cable materials.

Full choice of insulating compounds

Only three major companies give you a choice of *either* oil-base or butyl-base insulation. Rome Cable is one of these three and offers a choice of Rozone A (butyl-base) and Rozone (oil-base) insulations.

And, in addition, Rome can offer you a *polyethylene* insulation for high voltages.

You can match your operating needs more closely with cable insulation that puts the emphasis on what you want most—resistance to heat, moisture, ozone cutting, or any combination of properties. You can be sure of this choice when the cable is made by Rome Cable.

Getting the right jacket

In modern jacket materials, too, the same kind of freedom works to your advantage. You get a choice, with Rome Cable, of Roseal (special flame-retardant polyethylene); Roprene (a Rome-developed neoprene compound for use with rubber insulations); Rolene (polyethylene); and several other high-quality jacketing compounds. Each has its own advantages, depending on your requirements.

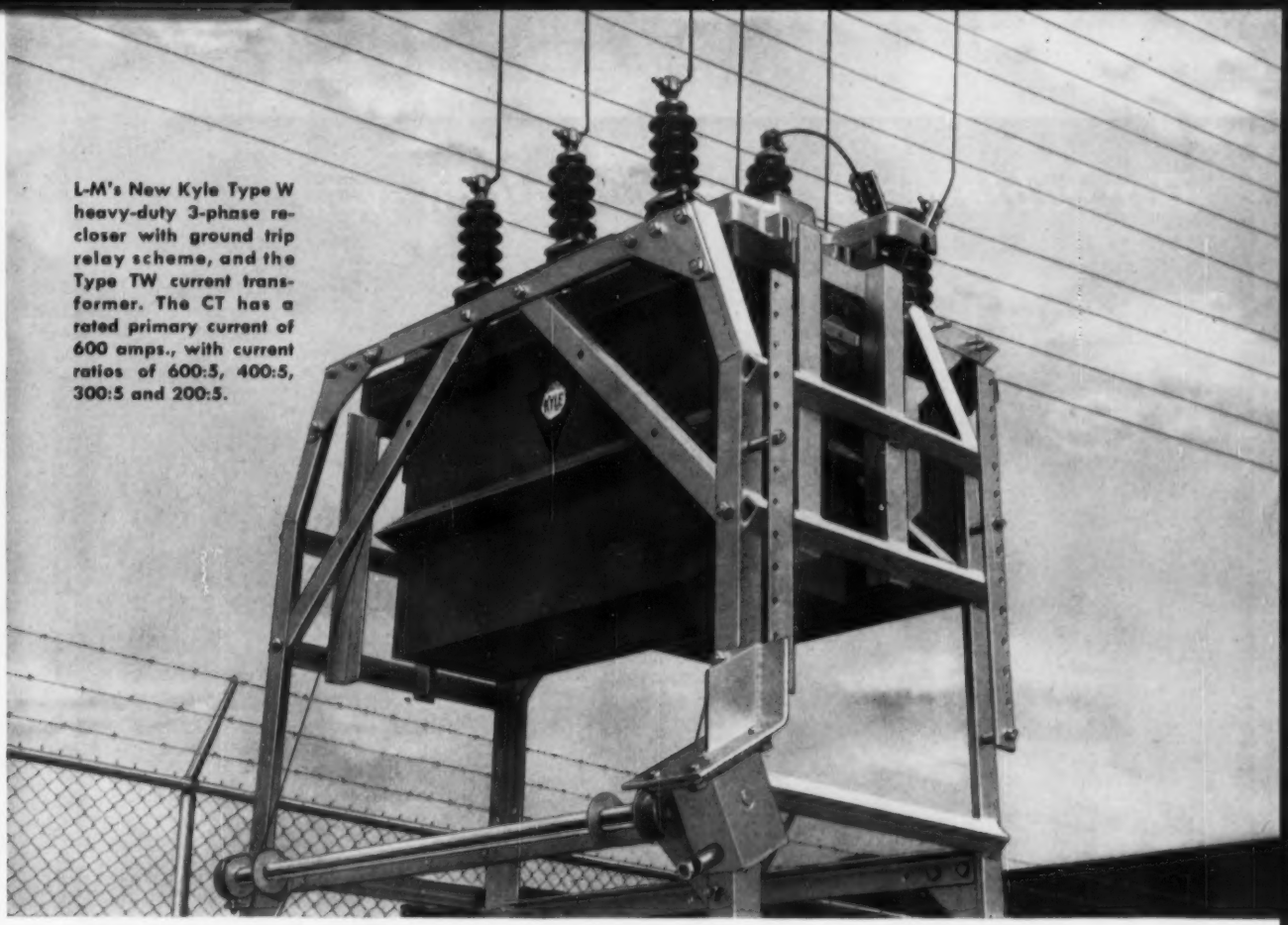
Bring your cable problems to Rome

When you discuss your premium cable requirements with your Rome Cable representative, you can count on his recommending the *right* cable for you. No matter what type of cable you choose, take advantage of Rome's ability to offer you a *real* choice.

For more information on the choice you get with Rome's power cable, contact him now—or write to Department 713, Rome Cable Corporation, Rome, New York.

ROME CABLE

CORPORATION



L-M's New Kyle Type W heavy-duty 3-phase recloser with ground trip relay scheme, and the Type TW current transformer. The CT has a rated primary current of 600 amps., with current ratios of 600:5, 400:5, 300:5 and 200:5.

At Half the Cost of OCB's...

Substation Type W Recloser Gives Greater Protection With Fast 2½-Cycle Clearing

By **FRANK McSTAY**, Product Manager, Kyle Products, Line Material Industries

Now, with L-M's new high-speed Type W Recloser, conductor burn-down of distribution feeder circuits is reduced to a minimum. This completely automatic and self-contained 3-phase unit clears so rapidly that up to 90% of the faults on typical distribution systems are prevented from becoming permanent. In fact, the Kyle Type W clears in less than half the time of distribution oil circuit breakers. This instantaneous opening results in better fuse coordination and helps to confine permanent faults to a small area.

The Type W also offers another advantage: by reducing the length of time during which fault current flows, the recloser permits using larger transformers without increasing the size of the wire on the system, or necessitating reactors to limit the available fault current.

200 MVA for Half the Cost

Besides safeguarding the distribution circuit, the 3-phase Type W offers large savings in both initial investment and maintenance. The unit is approximately half the price of an equivalent OCB for the same application.

Series over-current tripping is utilized with a selection of five time-current characteristics—fast, retarded, or extra retarded—in two degrees of slope—with 2, 3, or 4 operations to lockout, in many combinations of operations. In addition, L-M has a complete line of auxiliary equipment to provide almost any supplementary relaying scheme.

Ratings from 100 to 560 Amps.

L-M's Type W is available in normal load ratings from 100 to 560 amperes, with symmetrical RMS interrupting ratings up to 12,000 amperes at 4.8 kv and below, 10,000 amperes at 8.32 kv and below, and 8,000 amperes up to 14.4 kv. Current ratings can be changed in the field by simply replacing the series trip coils.

Get Complete Information

Ask the L-M Field Engineer for Bulletin CRIW giving more information on how L-M's new Type W recloser can be profitably applied to your system. Or write Line Material Industries, Milwaukee 1, Wisconsin. In Canada: Canadian Line Materials, Ltd., Toronto 13, Ontario.

McGRAW-EDISON

LINE MATERIAL Industries Kyle® Reclosers

McGRAW-EDISON COMPANY

313

Along today's modern highways easy-to-handle J-M Transite Ducts provide installation economies and years of service life, protecting traffic-signal, lighting, and other power-service circuits.

J-M Transite® Ducts install fast to last... give complete cable protection.

Because speed and economy set the pace in today's highway programs, more and more highway cables are going into Johns-Manville Transite Ducts.

For speed, Johns-Manville Transite Ducts are strong, light and long—easy to handle and install. Workmen set 10-foot lengths in place easily, join them up tight in seconds with snug-fitting J-M Plastic Couplings, and Transite's smooth bore is free of burrs and other obstructions that may interfere or cause damage during pulling of cables.

For economy, J-M asbestos-cement Transite Ducts go in to stay. Non-conductive Transite is not affected by electrolysis—resists the corrosive action of fills or high-salt soils in permanently damp locations. Millions of feet of installed Transite Ducts have proved that Transite withstands earth loads and soil stress . . . resists vibration and shock from highway traffic.

Let us send you free Transite Duct brochure EL-29A. Write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

JOHNS MANVILLE JM PRODUCTS

Johns-Manville Asbestos Transite Ducts can be laid directly in trench without concrete envelope or other mechanical protection.

JOHNS-MANVILLE Transite Ducts

Made of Asbestos-Cement

J-M Conduit for direct buried banks and exposed runs
J-M Korduct® for concrete banks

DOW CORNING CORPORATION

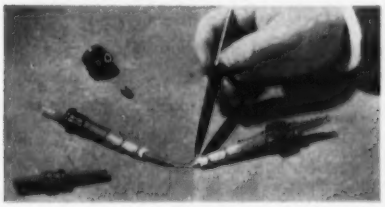
Silicone Dielectrics

ELECTRICAL AND ELECTRONIC NEWS No. 14

Silastic Withstands Heat and High Voltage on Spark Plug Lead

Selecting a rubbery insulating material that would withstand up to 15,000 volts at 400 F in aircraft spark plug lead assemblies posed no problem for design engineers at Scintilla Division, Bendix Aviation Corporation, Sidney, New York. Already familiar with Silastic*, the Dow Corning silicone rubber, they knew it has excellent resistance to moisture and retains good mechanical and dielectric properties even after prolonged exposure to heat and high voltages.

Actually, Scintilla uses Silastic in four different areas on the new Bendix lead: for the inner and outer layers of the cable; for the molded terminal insulators; and as an interlayer to separate the three courses of



braided metal sheathing. Interlaying the braided sheathing with Silastic not only keeps moisture out, but protects the sheathing against vibration to give it longer life.

The new Silastic insulated lead is now standard for the Wright turbo compound 18 cylinder, 3350 hp engine that powers the DC 7, the Super Constellation and various military aircraft. *No. 54*

*T. M. REG. U. S. PAT. OFF.

Dow Corning Silicone Lubricants, including oils and greases, are described in a new, illustrated 8-page brochure that gives their properties, lists their applications, and cites factors which contribute to obtaining longer life. *No. 55*

NEW SILICONE INSULATING RESINS FLOW FREELY WITHOUT SOLVENTS

Two new free-flowing, solventless silicone electrical resins are now available from Dow Corning in commercial quantities. Identified as R-7501 and R-7521, these 100% silicone resins are ideal for impregnating or encapsulating miniature and subminiature motors, transformers and other electrical and electronic assemblies.

Since both new resins pour freely, they quickly saturate and fill all voids in even the most complex assemblies, thus eliminating the problem of insulation punctures caused by escaping solvent gases. As shown in the photo, Dow Corning R-7521 is more fluid at room temperature and penetrates much deeper into 20-40 mesh sand than a conventional epoxy resin.

Both of the new resins cure to a strong, bubble-free mass having excellent dielectric properties, good thermal conductivity and high moisture resistance. When cured, they readily withstand continuous service at 400 F ambients and intermittent exposure to temperatures up to 500 F.

At room temperature the viscosity of R-7501 is 2500 centistokes and the viscosity of R-7521 is 100 centistokes. Either resin may be thinned by warming to 175 F. If desired, the resins can be blended together to obtain any intermediate viscosity.

The resins are cured by adding a peroxide catalyst and heating at temperatures up to 390 F. Shelf life of the uncatalyzed resins is well over a year; pot life of the catalyzed resins at room temperature is over six months. Dow Corning R-7501 and R-7521 can be used as received or combined with a wide range of inorganic fillers. *No. 53*

Silicone Insulated Motor Still on Test after 66,080 Hours at 240C

At 10 A. M., June 3, 1946, a silicone insulated 5 hp motor was generator loaded to operate at its test temperature of 240 C in Dow Corning's motor test labs. Every 500 hours since the test began, the motor has been shut down and exposed to 100% relative humidity for 24 hours. As of 11 A. M. August 1, 1957, this motor was still on test after 66,080 hours at an average copper temperature of 240 C! That's equivalent to 404 years operation at the Class H temperature of 180 C. *No. 56*

Silicone Materials in Appliance Design, a recent article in ELECTRICAL MANUFACTURING, lists a variety of applications for several different silicones in appliances; describes how silicones have made possible design changes heretofore impractical, and how they extend service life and dependability. To receive your copy, circle *No. 57*

Parts and components made with Dow Corning Silicone Molding Compounds are lightweight, show excellent resistance to heat, and have good structural and electrical properties. Used as brush holders, collector rings, terminal boards, multiple lead connectors, heat dams for turbine driven alternator bearings, and aircraft brake shoe backing. *No. 58*

Send Coupon for More Information

DOW CORNING CORPORATION - Dept. 4122
Midland, Michigan

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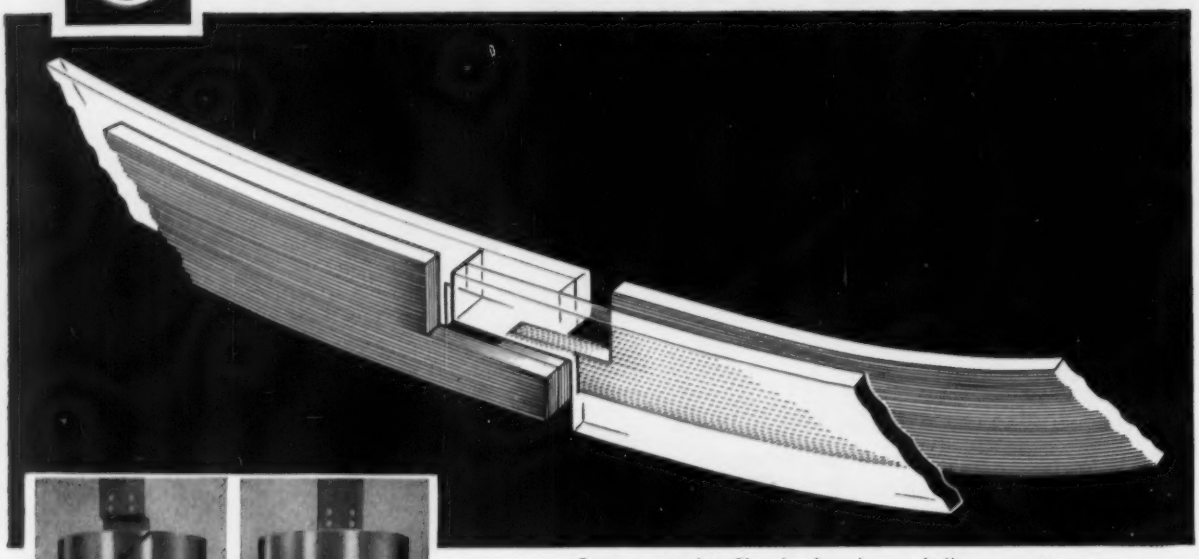

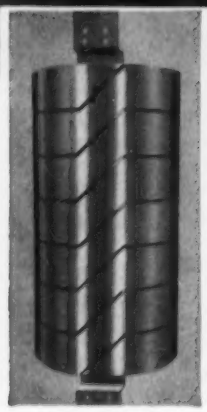

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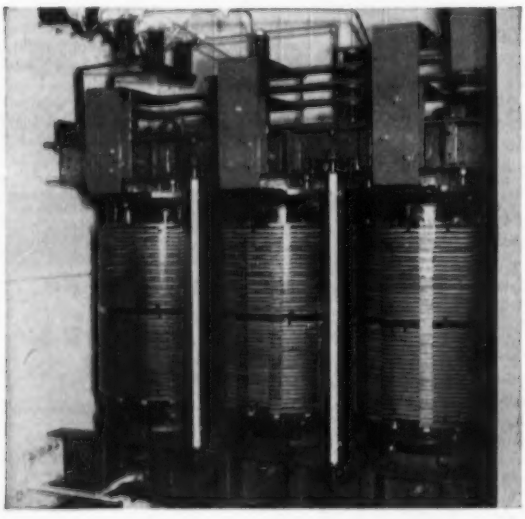

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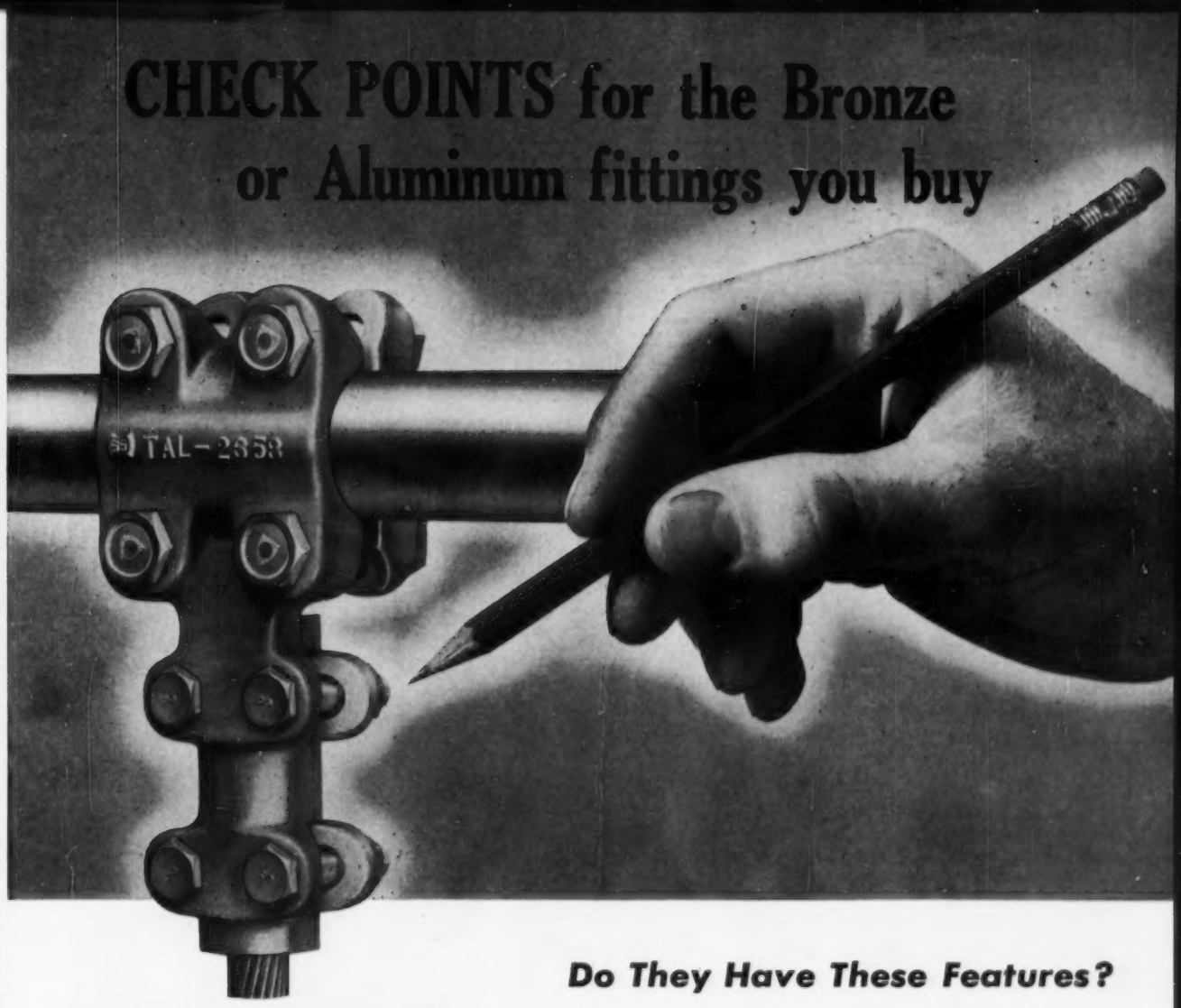

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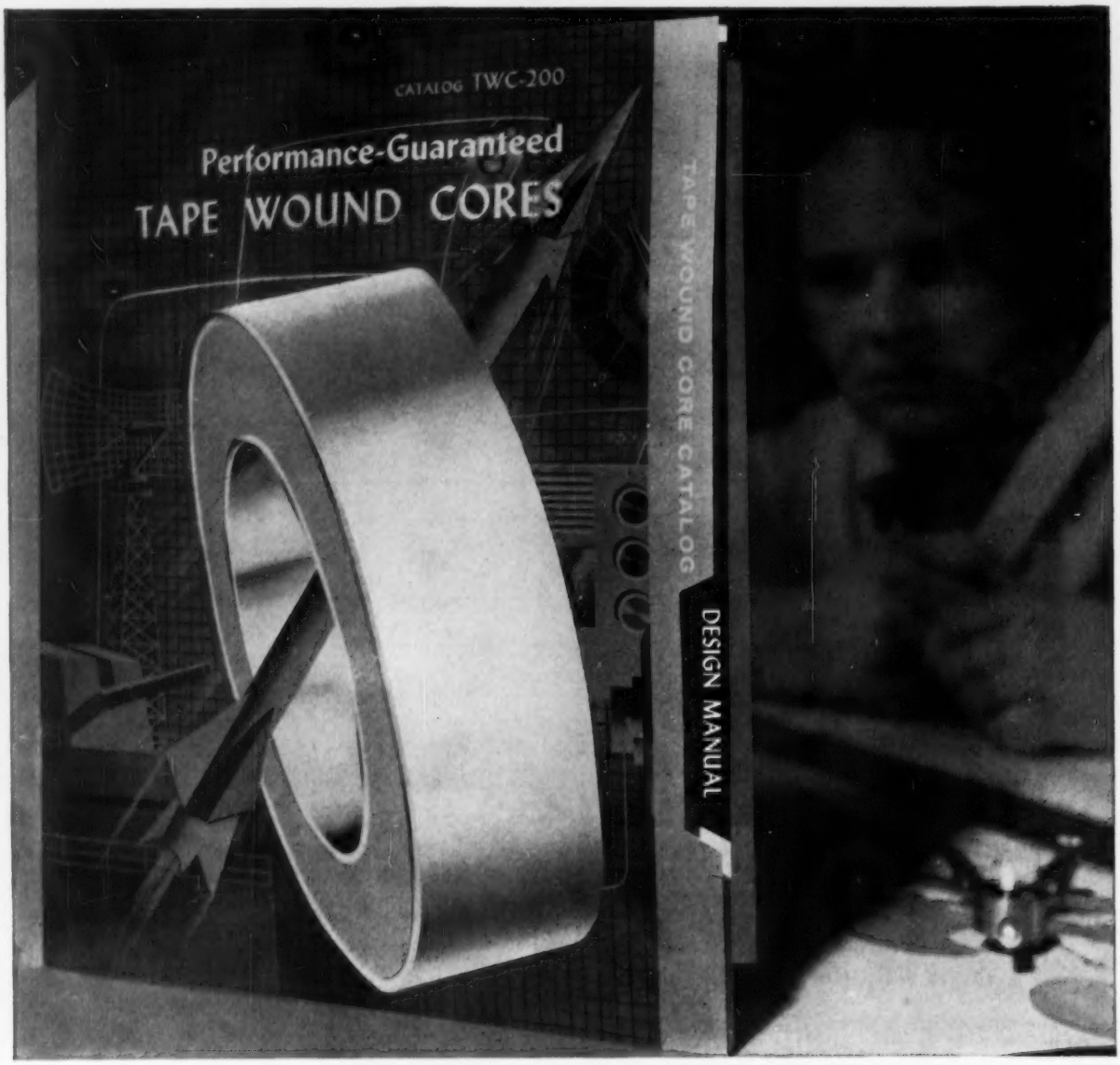

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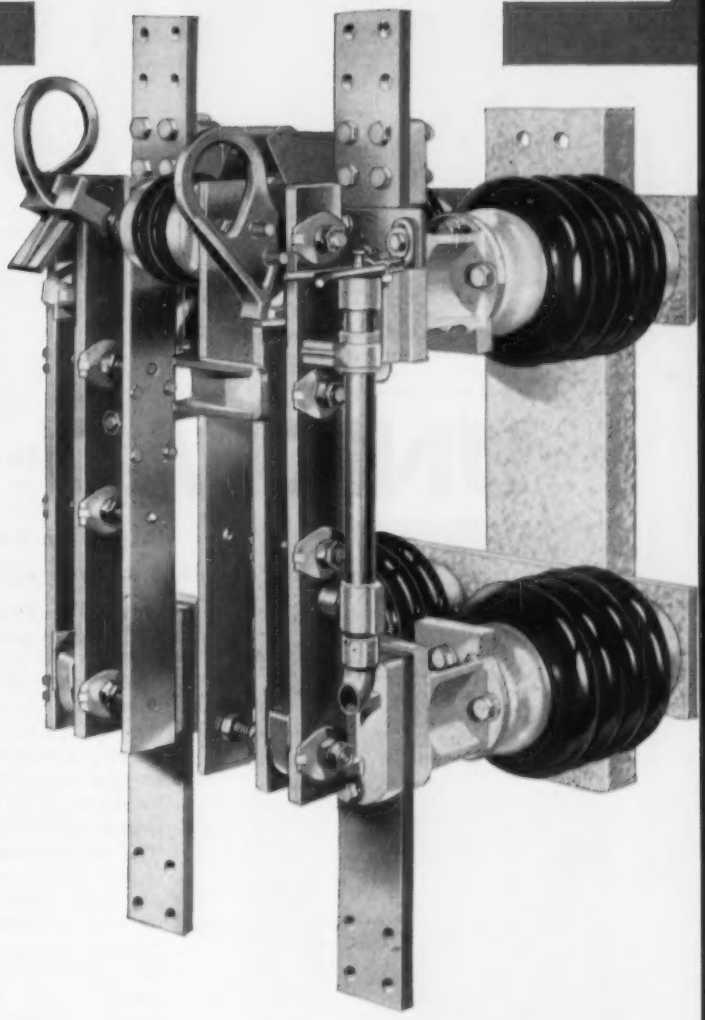

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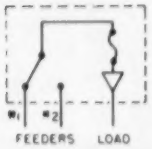
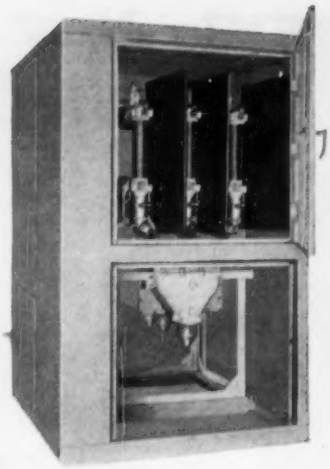
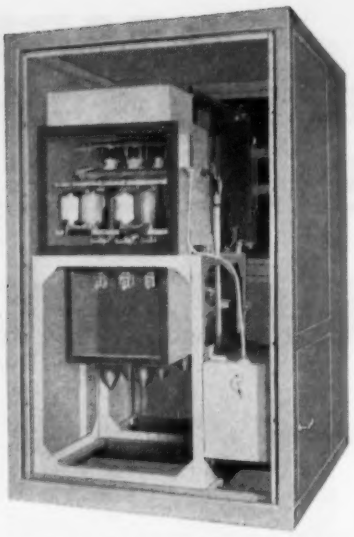




Right side opened to show disconnecting type power fuses and load cable pothead. The pothead can be 3 conductor as shown or 3 single conductor.



Left side panel and cover plates removed to show details of oil switch (with control transformers) and of cable terminating compartment. Also note Model "F" automatic operating mechanism. Oil switches can be furnished for full load break manual operation instead of automatic.

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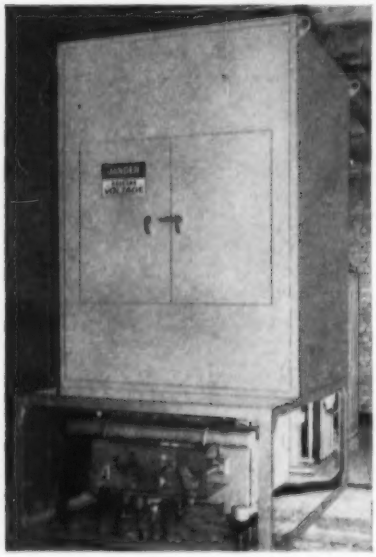

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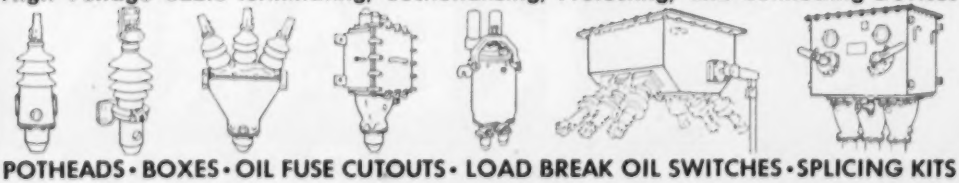

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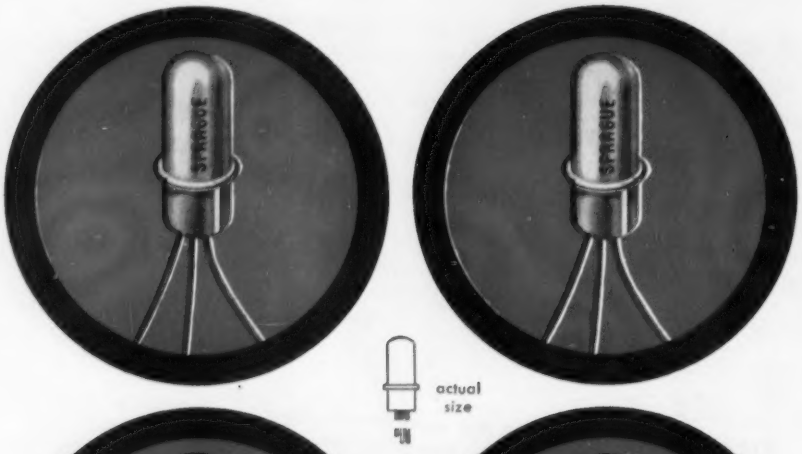

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Fine-Particle Magnets

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F. E. LUBORSKY

The unusual properties of fine-particle magnetic materials offer challenging opportunities for research aimed at the development of powerful new permanent magnets. In this article, the permanent-magnet properties of fine particles are summarized and compared with those predicted on a theoretical basis.

RECENT ADVANCES in solid-state physics have resulted in such important by-products as transistors and fine-particle magnets. The unusual properties of extremely fine particles are therefore doubly significant in that they contribute to a more fundamental understanding of magnetic materials and, at the same time, offer challenging opportunities for applied research aimed at developing powerful new permanent magnets (*Electrical Engineering*, Feb. 1957, pp. 170-71). The purpose of this article is to provide the engineer interested in magnets with a physical picture of their structure and an insight into the basic factors which determine their behavior. The "state of the art" of domain theory as it pertains to high-coercive-force materials is briefly reviewed, and the permanent-magnet properties of fine particles are summarized and compared with those predicted from theoretical considerations.

MAGNETIC DOMAINS

AN UNMAGNETIZED BAR OF IRON placed in a magnetic field of a fraction of a gauss acquires an induced magnetism of many thousand gausses. How do we account for this remarkable effect? The general nature of this phenomenon was outlined 50 years ago by the French physicist, Pierre Weiss.[1] He postulated two essential requirements for ferromagnetic materials: The atoms themselves must possess an inherent magnetic moment, and there must exist between the atoms a nonmagnetic "molecular field" which aligns their atomic magnetic moments. Weiss pointed out that the "molecular field" would only hold the atomic magnetic moments parallel in local regions of a crystal, and that over larger volumes other regions with different directions of magnetic alignment would occur. An "unmagnetized" iron bar is therefore a misnomer, for internally iron is magnetized to saturation at all points. We say an iron bar is "unmagnetized" when we can detect no external field because its inherent magnetization is subdivided into domains with mutually canceling directions of magnetization. The magnetic flux is there, but it is circulating entirely within the bar. A relatively weak magnetic field is sufficient to orient the already magnetized domains of the "unmagnetized" bar, giving rise to the observed strong external magnetic field. In this way, Weiss' Domain Theory satisfactorily accounts for the behavior of ferromagnetic materials.

Weiss' classical theory did not explain why only a few atoms possess an inherent magnetic moment, and only certain crystal structures give rise to the "molecular field." As knowledge of atomic physics evolved, however, it became apparent that the atomic magnetic moment of ferromagnetic materials is associated with a net unbalance of electron spins, certain electron shells containing more electrons spinning in one direction than the other. Quantum concepts were then applied by Heisenberg[2] to account for Weiss' "molecular field" in terms of the exchange interaction force. This essentially electrostatic effect aligns the unbalanced electron spins and their associated magnetic moments. The exchange forces also interact with the material mechanically, producing magnetostrictive effects, and they interact with the atomic crystal structure to make certain preferred directions within the crystal lattice easy directions of magnetization. In the cubic iron crystal, for example, the cube edges are easy directions of magnetization, whereas the cube diagonals are relatively difficult. It is because of this "crystal anisotropy" that the crystals in high-quality transformer steels are oriented with their cube edges parallel to the magnetization direction.

On the atomic scale, then, we can visualize an unbalance of electron spins conferring a net magnetic moment upon certain atoms, and interatomic exchange forces aligning these magnetic moments to give rise to ferromagnetic domains oriented along certain preferred crystal directions. Now let us examine more closely the nature of the region that divides adjacent magnetic domains. This "domain boundary" is of great practical significance because its behavior largely determines the useful engineering properties of magnetic materials.

The Magnetic Domain Boundary. The first successful model of a domain boundary was proposed by Bloch,[3] who showed that the change in the direction of magnetization occurring between adjacent domains does not take place abruptly in one plane of atoms, but extends over hundreds of atomic planes (Fig. 1). This

Condensed text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., Jan. 21-25, 1957. Recommended for publication by the AIEE Committee on Basic Sciences.

T. O. Paine, L. I. Mendelsohn, and F. E. Luborsky are with the General Electric Company, West Lynn, Mass.

The authors wish to acknowledge many stimulating discussions with J. H. Hollomon, J. C. Fisher, C. P. Bean, I. S. Jacobs, and W. H. Meiklejohn of the General Electric Research Laboratory.

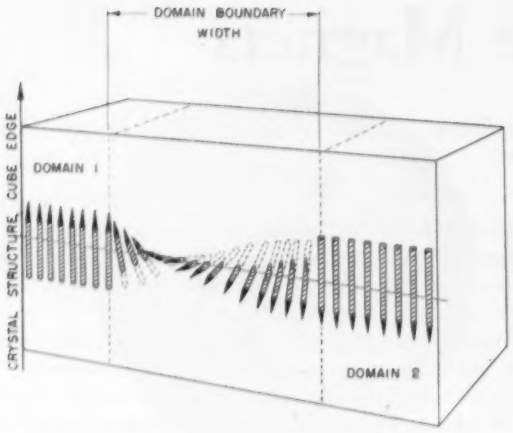

Fig. 1. Magnetization across a domain boundary (after Kittel[7]).

spreading out of the domain boundary comes about because the exchange forces are attempting to align the electron spins closely, and the misalignment between adjacent atoms can be reduced by including more atoms in the boundary region. Crystal anisotropy, on the other hand, acts to minimize the number of atoms involved in the boundary, inasmuch as the magnetic moments of these atoms are forced away from an easy crystal direction. The width of the domain boundary thus represents a compromise between the opposing demands of exchange and crystal anisotropy forces. Numerical values for exchange energy and crystal anisotropy can be obtained by measuring various characteristics of materials. For example, the Curie temperature at which ferromagnetism disappears because of thermal misalignment provides an indication of the strength of exchange energy, whereas the magnetic field required to rotate domain magnetization to complete saturation provides a measure of crystal anisotropy. From such information, and other more direct measurements, it is possible to calculate to a first approximation both the width and the surface energy of domain boundaries. These calculations agree reasonably well with experiments which demonstrate that domain boundaries have a small but definite thickness and surface energy.

Thus, we have a physical picture of a magnetic domain boundary in terms of fundamental forces, and we can visualize boundary motion as a wave of changing spin orientations traveling through the material. Now let us consider the effect of an applied magnetic field, to understand more fully how domain-boundary movement leads to the familiar S-shaped magnetization curve.

The Magnetization Curve. Domain theory accounts for the three regions of a typical magnetization curve in terms of three basic processes: first, domain-boundary stretching; second, the growth of favorably oriented domains by continuous domain-boundary movement; and third, rotation of domain magnetization (Fig. 2). The reversible initial permeability region can be attributed to the elastic stretching of domain boundaries around crystal imperfections; the steep irreversible portion of the magnetization curve takes place as the domain boundaries break away from the crystal imperfections and move continuously through the material, allowing domains favorably oriented with respect to the magnetizing field to consume their less favorably oriented neighbors; and the upper reversible knee of the curve occurs as the fully grown domains rotate their magnetization against strain and crystal anisotropy forces into close alignment with the magnetizing field. The saturation magnetization B_{is} is then approached, but when the magnetizing field is removed the anisotropy forces rotate the domains back into easy directions of magnetization, reducing induction to the residual point B_r. This latter process can be suppressed by orienting the crystals along an easy direction of magnetization, or by introducing directional strains. A "square loop" material then results. By applying a reverse field, the boundaries can be moved back to their original position. The field required to accomplish this is the coercive force H_{ci}, the measure of a material's resistance to demagnetization.

This simplified physical picture of the magnetization process indicates the great practical importance of understanding and controlling domain-boundary movement. Two opposite extremes of controlled boundary motion are of commercial interest. For efficient transformer steels, domain boundaries must be made to move very easily in response to low fields, whereas for powerful permanent magnets, domain-boundary motion must be made very difficult so the magnets can withstand strong demagnetizing fields. This leads us to a fundamental statement of the permanent-magnet problem: How can we prepare a material with the maximum domain stability?

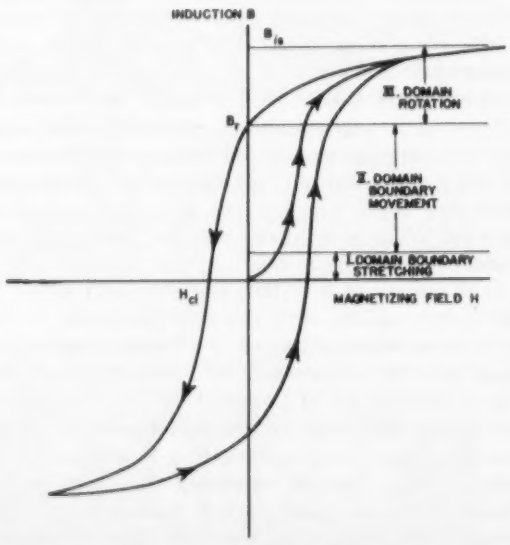

Fig. 2. Understanding magnetization in terms of domain theory.

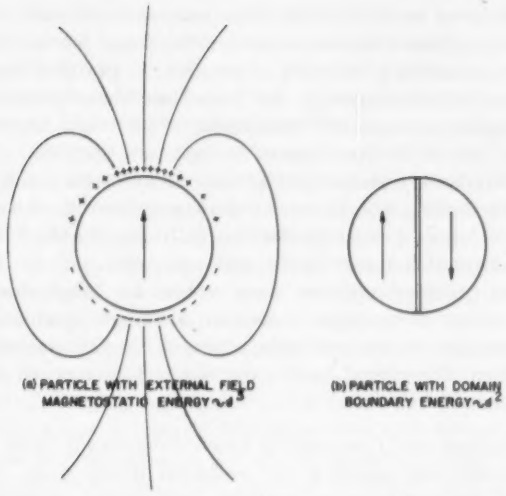

Fig. 3. Comparing magnetostatic and domain boundary energies.

THE PERMANENT-MAGNET PROBLEM

ONE OBVIOUS APPROACH to this problem is to impede domain-boundary motion by introducing structural inhomogeneities into the material. We might visualize a domain boundary enveloping a nonmagnetic inclusion and thereby reducing its surface area by an amount equal to the cross-sectional area of the inclusion. To move the boundary away from the inclusion, the surface area must again be generated. Inasmuch as this requires energy, the coercive force of the material should be increased. Néel[4] has pointed out a less apparent but much more potent barrier to domain-boundary movement: the complex "Néel Spike" domain pattern which forms in the vicinity of nonmagnetic inclusions and effectively entangles domain boundaries attempting to pass. Thus, nonmagnetic inclusions distributed throughout a material markedly increased its resistance to demagnetization by obstructing domain-boundary movement. The quench-hardened chrome-steel magnets apparently derive their properties from this mechanism, the nonmagnetic inclusions being precipitated carbides. These magnets, however, develop only a small resistance to demagnetization. This is apparently inherent in the inclusion mechanism, which Néel[5] has shown cannot account for coercivities above several hundred oersteds. How else can we stabilize domains, then, to achieve greater coercivities?

The answer is found by applying our knowledge of the dimensions and energies of domain boundaries in a more imaginative manner. Instead of trying merely to impede domain-boundary motion, let us completely eliminate these troublesome easily moved boundaries. This certainly sounds like a promising approach, but how do we go about preparing a material free of domain boundaries? From our picture of a domain boundary we know that it has a small but finite width and surface energy. If we prepare particles of about the same diameter as the domain-boundary width, perhaps they will be too small to contain a boundary. This leads us to the concept of the "single-domain" particle, whose interesting properties provide the key to an understanding of modern high-coercive-force permanent-magnet materials.

The Single-Domain Particle. Frenkel and Dorfman[6] first suggested in 1935 that a sufficiently small particle would contain but one magnetic domain. Their reasoning may be followed by referring to Fig. 3, which compares two alternative energies: the magnetostatic energy associated with a particle having an external magnetic field, and the domain-boundary surface energy which must be introduced into the particle to eliminate the external field. In bulk materials, the boundary energy is negligible compared with the external field energy, but this situation reverses at a sufficiently small particle diameter. This comes about because the magnetostatic energy is a volume effect proportional to the cube of particle radius, while the domain-boundary energy is associated with an area proportional to the square of the radius. As the particle diameter decreases, then, the volume magnetostatic energy falls off more rapidly than the domain-boundary surface energy. Below some critical particle size there is less energy associated with an external field than with a domain boundary; this is the critical diameter below which single-domain particles exist. We can roughly calculate domain-boundary energies, as we have seen, so it is possible to estimate the critical diameters for single-domain particles of various materials. These are summarized in Table I. The reader interested in a more complete discussion is referred to recent review articles.[7,8]

The single-domain particle thus makes possible the preparation of materials containing no domain boundaries, materials whose magnetization can only change by the simultaneous rotation of atomic magnetic moments. This can be made a much more difficult process than simple domain-boundary motion.

The Coercive Force of Single-Domain Particles. Having no domain boundaries to move, a single-domain particle's coercive force is determined by the anisotropy forces which oppose domain magnetization rotation. There are four forces which may act: crystal anisotropy, strain anisotropy, shape anisotropy, and exchange anisotropy. Each will be briefly described.

Table I. Critical Diameter and Coercive Force of Single-Domain Particles

Material	Estimated Critical Diameter, microns	Intrinsic Coercive Force, oersteds		
		Calculated Values		Observed Values
		Crystal Anisotropy	Shape Anisotropy	
Manganese-Bismuth	0.5	30,000	3,900	12,000 (crystal)
Barium Ferrite	1.0	16,000	2,500	4,500 (crystal)
Iron	0.002	500	10,700	2,100 (shape)

Crystal anisotropy directs the magnetization of a single-domain particle along an easy crystallographic direction as previously discussed. In order to rotate the

particle's magnetization, an applied magnetic field must provide enough energy to rotate the magnetization through a difficult crystal direction. Kittel[9] has shown that the resulting coercive force is given by

$$H_{ci} = \frac{2K}{I_s} \qquad (1)$$

where H_{ci} is the coercive force in oersteds, K the crystal anisotropy constant in ergs per cubic centimeter, and I_s the magnetization in gausses. Substituting appropriate values in this equation, we obtain these coercivities for various materials: iron 500 oersteds; nickel 150 oersteds; cobalt 6,000 oersteds; barium ferrite 16,000 oersteds; and manganese-bismuth 30,000 oersteds. Here are some obviously promising opportunities for permanent magnet development.

Strain anisotropy directs the magnetization of a strained particle along a preferred direction with respect to the strain. Stoner and Wohlfarth[10] have predicted that this magnetostrictive effect should lead to increased particle coercive force in the same manner as crystal anisotropy. The maximum coercive force resulting from strain anisotropy is estimated to be 600 oersteds for iron and cobalt and 4,000 oersteds for nickel. No experimental confirmation of a strain effect on particle coercivity has yet been reported.

Shape anisotropy has been discussed by various physicists,[10-12] who point out that magnetization along the length of an elongated single-domain particle produces the minimum magnetostatic energy. To rotate the particle's magnetization across its width, additional magnetostatic energy must be stored in its external field. Stoner and Wohlfarth have made detailed calculations for ellipsoids, with various simplifying assumptions. For a very long cylindrical particle they suggest that

$$H_{ci} = 2\pi I_s = \frac{B_{is}}{2} \qquad (2)$$

where I_s is the saturation magnetization and B_{is} the intrinsic saturation induction in gausses. This relation predicts these maximum coercive force values for highly elongated single-domain particles: iron 10,700 oersteds; cobalt 9,000 oersteds; manganese-bismuth 3,900 oersteds; nickel 3,050 oersteds; and barium ferrite 2,300 oersteds. More recently, Jacobs and Bean[13] have proposed a modified shape-anisotropy model in which simultaneous parallel rotation of all the spins does not take place, but instead the particle acts as a chain of mutually interacting spheres. Their calculations predict a maximum particle coercive force of 2,700 oersteds for iron. This model agrees quite well with experimentally observed values reported by the authors.[14-16]

Exchange anisotropy is a new magnetic phenomenon discovered by Meiklejohn and Bean[17] in experiments with single-domain particles of oxidized cobalt. It leads to a unique unidirectional preferred magnetization apparently stemming from an exchange interaction between cobalt metal and its "antiferromagnetic" oxide shell. By aligning such a particle in a magnetic field, its entire hysteresis loop can be displaced; indeed it can be displaced so far that the most powerful magnetic fields now available cannot permanently reverse particle magnetization. It is too early to predict the practical significance of this discovery, but a displaced-loop permanent magnet based on the Meiklejohn effect would represent the first really "permanent" permanent magnet.

We have reviewed the various factors which may oppose domain rotation, and thus contribute to the coercive force of a single-domain particles. Table I summarizes this information, and compares the predicted and observed coercive force values for single-domain particles of various materials. Although quantitative confirmation has not been achieved, the correlation between theoretical and experimental values is noteworthy.

Aligning and Compacting Single-Domain Particles. We should now consider the problems involved in aligning and compacting particles into useful permanent magnets. Particle alignment and packing are factors of great importance in determining magnet characteristics.

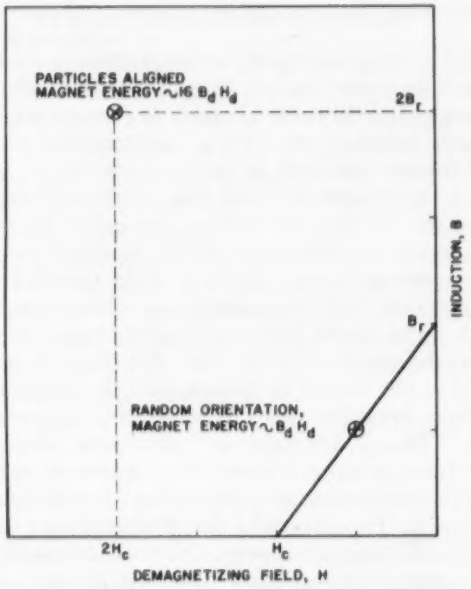

Fig. 4. Ideal relation between particle alignment and magnet energy.

Particle alignment is significant because particles randomly oriented with respect to the magnetizing field have their magnetization vectors rotated into alignment with the field only at saturation; when the saturating field is removed, the magnetization vectors are rotated by the anisotropy forces back into an easy direction of magnetization. For a group of randomly oriented particles of uniaxial anisotropy, the average decrease in induction from saturation induction B_{is} to residual induction B_r is 50%. With a cubic anisotropy effect, the magnetization vector of a randomly oriented particle

can never be more than 45 degrees from an easy direction, so the loss in induction because of randomly oriented particles may be only 10%. In addition to this effect on induction, Néel[18] has shown that the coercive force of randomly oriented cubic anisotropy particles is only 30% of the aligned coercive force. Stoner and Wohlfarth predict for randomly oriented uniaxial particles a reduction in coercive force of 50%, but there is a slight increase with the Jacobs and Bean model. With alignment possibly doubling both the residual induction and the coercive force, the maximum energy product of a fine-particle magnet is extremely sensitive to alignment; in fact, under ideal conditions alignment can increase the maximum energy product of a fine-particle magnet by as much as a factor of 16, as indicated in Fig. 4. Particle alignment thus is an important factor contributing to the energy of fine-particle magnets, affecting coercivity, residual induction, and maximum energy product.

Particle packing has one obvious effect: packing single-domain particles more closely together directly increases the induction of the compact. If the particles begin to contact each other physically, however, there is the possibility of reducing their coercive force through loss of single-domain behavior. If this is overcome, fine-particle magnets have their optimum energy product at the greatest possible packing, where the induction is highest. This does not hold in the case of magnets based upon shape anisotropy, however, where the additional effect of particle interaction must be considered. In 1947, Néel[11] suggested from magnetostatic energy considerations that the relation between the intrinsic coercive force of an elongated single-domain particle at infinite dilution and its coercive force in a compact is given by

$$H_{ci}\ \text{compact} = H_{ci}\ \text{particle}\ (1\text{-}p) \qquad (3)$$

where p is the packing fraction of the particles. This relationship has been experimentally confirmed by Weil[19] and the authors.[15,16]

Since the coercivity decreases and the induction increases as elongated particles are packed together, the optimum energy product for shape anisotropy fine-particle magnets occurs at an intermediate packing fraction, representing the best compromise between coercivity and induction. For ideal, highly elongated, perfectly aligned single-domain prolate ellipsoids of iron, the magnetic properties should be related to the packing fraction as shown in Fig. 5. It is interesting to note that this leads to a maximum possible energy for a hypothetical magnet compacted from ideal particles of 38.8 million gauss-oersteds, with $B_r = 14{,}300$ gausses and $H_c = 3{,}600$ oersteds.

We have briefly reviewed the major factors involved in fine-particle magnet behavior, and we can understand the properties of these materials by visualizing large numbers of single-domain particles responding to a demagnetizing field by rotating their domain magnetization vectors against anisotropy forces. This process is quite different from the domain-boundary movement occurring in transformer steels, although there is a superficial similarity in the appearance of the hysteresis loops of the two types of material. There are still many gaps in our understanding, but we have learned a great deal in recent years, and rapid progress is being made. Let us see how these concepts are being applied in new materials.

FINE-PARTICLE MAGNETS – THEORY AND PRACTICE

THREE PRINCIPAL MATERIALS have been studied to date: manganese-bismuth, barium ferrite, and iron. They will be reviewed in order.

Manganese-Bismuth. Guillaud's[20] classic study of manganese-bismuth in 1943 clearly established the dependance of fine-particle coercivity on crystal anisotropy. He demonstrated that cooling fine particles of manganese-bismuth below room temperature causes the intrinsic coercive force to decrease in direct proportion to crystal anisotropy, both becoming zero at 84 degrees Kelvin. He also studied the effects of particle size and alignment on coercivity, observing that particles below 3 microns in diameter have an intrinsic coercive force at room temperature of 12,000 oersteds. Later he described the aligning and compacting of manganese-bismuth particles into fine-particle magnets.[21] More recent work by Adams, Hubbard, and Syeles[22,23] produced the excellent permanent-magnet properties shown in Fig. 6 and Table II; energies of 5.3 million gauss-oersteds have been achieved. A recent study by Roberts[24] provides a great deal of information on the structure of this compound.

Table II. Permanent-Magnet Properties of Fine Particles

Material	B_r, gauss	H_{ci}, oersteds	H_c, oersteds	BH_{max}, gauss-oersteds $\times 10^6$
Manganese-Bismuth	4,800	—	3,200	5.3
Calculated upper limit	7,800	30,000	7,800	15.0
Non-oriented Barium Ferrite	2,100	1,850	1,750	0.95
Oriented Barium Ferrite	4,000	2,100	1,950	3.5
Calculated upper limit	4,650	16,000	4,650	5.4
Formate Iron	6,000	500	475	1.0
Elongated Iron	8,950	715	705	3.5
Calculated upper limit	14,300	3,600	3,600	39.0
Formate Iron-Cobalt	8,600	425	410	1.6
Elongated Iron-Cobalt	9,050	1,050	1,025	5.0
Calculated upper limit	16,300	4,100	4,100	50.0

Fine particles of manganese-bismuth have an intrinsic coercive force of 12,000 oersteds; the intrinsic saturation induction is 7,800 gausses. The energy product of a square-loop permanent magnet is not raised by increasing its intrinsic coercive force beyond half its residual induction; even at infinite intrinsic coercive force, the maximum energy product is given by $(B_r/2)^2$. Assuming perfect particle alignment and a packing factor of unity, the limiting energy product of manganese-bismuth is therefore 15 million gauss-oersteds. For a packing factor of 0.74, corresponding to close-packed spheres, the maximum energy product is 8.3 million gauss-oersteds. Thus, the 5.3 million gauss-oersteds obtained by Adams and his co-workers represents an appreciable

portion of the possible energy. Large-scale commercial applications of this interesting material have been impeded by the scarcity of bismuth, as well as by the unusually large temperature coefficient, which causes the material to lose half its coercivity and energy on cooling to −50 C.

Barium Ferrite. A new crystal-anisotropy fine-particle magnet material of the compound $BaO{\cdot}6Fe_2O_3$ was announced in 1952 by Went, Rathenau, Gorter, and van Oosterhout[25,26]; similar results are obtained by replacing the barium with lead or strontium. A directional material made by aligning the particles with a magnetic field during pressing was later described by Rathenau, Smit, and Stuijts[27] and by Fahlenbrach and Heister.[28] Table II and Fig. 6 show the properties achieved with both directional and nondirectional barium ferrite. As in manganese-bismuth, the high intrinsic coercive force and relatively low saturation induction removes coercivity as a problem as far as calculating the maximum possible energy is concerned. The intrinsic saturation induction is 4,650 gausses, so barium ferrite has a maximum possible energy product of 5.4 million gauss-oersteds with perfect particle alignment at unity packing factor. The 3.7 million gauss-oersteds reported by Sixtus[29] is thus more than two thirds of the ultimate.

Fine-Particle Iron. The first commercially produced fine-particle magnets resulted from work by Néel[30] and others on single-domain iron and iron-cobalt alloy particles made by the low-temperature reduction of iron formate. This material was produced in France for a brief time after World War II, and is now being made in England under the name of "Gecalloy." The process consists of dissolving scrap iron in formic acid at elevated temperature, after which the iron formate is precipitated and hydrogen reduced below 400 C in special furnaces. The resulting iron powder is protected from air by storage under a protective liquid, such as benzene or acetone. It is pressed into magnets with a protective organic binder to increase mechanical strength and inhibit oxidation. The resulting magnets

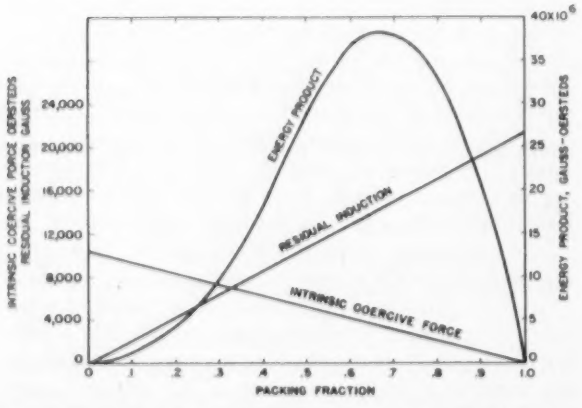

Fig. 5. Effect of packing on the magnetic properties of ideal elongated iron particles.

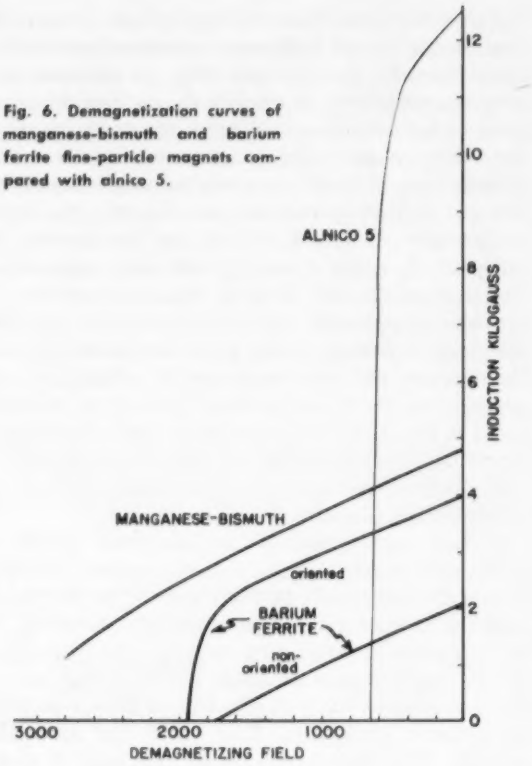

Fig. 6. Demagnetization curves of manganese-bismuth and barium ferrite fine-particle magnets compared with alnico 5.

have energy products ranging from 0.5 to 1.7 million gauss-oersteds.[31] Franklin[32] has shown that the formate-reduction process produces iron and iron-cobalt alloy particles which are essentially spherical in shape, except for slight random variations in particle dimensions.

The preparation of significantly elongated iron and iron-cobalt single-domain particles has recently been described by the authors.[14-16] These particles have a high coercivity derived from a pronounced shape-anisotropy effect, and have been aligned and compacted into shape-anisotropy fine-particle magnets as shown in Fig. 7. Table II and Fig. 8 summarize the results achieved to date with iron and iron-cobalt single-domain particles. These results show considerable progress, but only a tenth of the upper limit has been attained, so there is a great deal of room for improvement. The 5 million gauss-oersteds energy already achieved compares favorably with the energy of conventional alloy magnets. Fine-particle magnets have a number of other characteristics of great importance to the design engineer: they can be molded to precise dimensions, they are readily machined, their content of critical materials is low, they are very stable, and by controlling particle packing their demagnetization curves can be varied over a wide range. The future of these new materials appears very bright.

The Structure of Alloy Magnets. We have developed a physical picture of the relation between the structure and properties of fine-particle magnets which suggests

by analogy that conventional alloy magnets may operate on similar basic principles. This has been discussed by Stoner and Wohlfarth and many others, and an increasing amount of experimental evidence favors this hypothesis. In 1951, Geisler[33] showed the presence of a particle-like precipitate in the structure of various magnet alloys. Nesbitt, Heidenreich, Williams, and Bozorth[34-36] have concluded from electron-microscope studies and magnetic analysis of alnico that the shape anisotropy of an oriented single-domain precipitate contributes to its magnetic properties. In addition the authors[16] have recently duplicated the permanent-magnet properties of each of the eight alnico alloys by simulating its probable structure with fine particles similar in composition, shape, alignment, and packing fraction to the phase precipitated in each alloy. A great deal of work remains to be done before the complex permanent-magnet alloys are fully understood, but it appears likely that a "particle" effect of some sort plays an important role in every magnet. The concepts presented here should, therefore, provide the engineer who uses permanent magnets with an insight into the basic factors which determine their behavior.

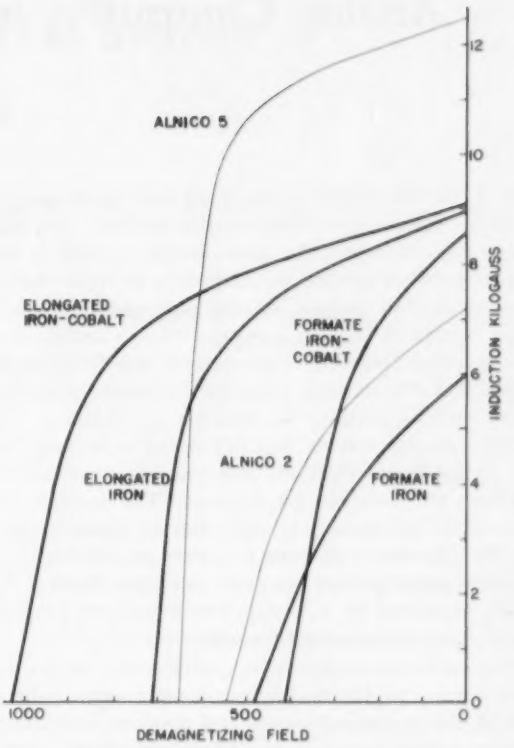

Fig. 8. Demagnetization curves of iron and iron-cobalt fine-particle magnets compared with alnico 5 and alnico 2.

Micrograph by E. Fullam, Inc.

Fig. 7. Elongated single-domain iron particles aligned and compacted into magnet.

REFERENCES

1. P. Weiss. *Journal de Physique*, Paris, France, vol. 6, 1907, pp. 661-90.

2. W. Heisenberg. *Zeitschrift für Physik*, Berlin, Germany, vol. 49, 1928, pp. 619-36.

3. F. Bloch. *Ibid.*, vol. 74, 1932, pp. 295-335.

4. L. Néel. *Cahiers de Physique*, Paris, France, vol. 25, 1944, pp. 21-44.

5. L. Néel. *Journal de Physique et le Radium*, Paris, France, vol. 17, 1956, p. 250.

6. J. Frenkel, J. Dorfman. *Nature*, London, England, vol. 126, 1930, pp. 274-75.

7. C. Kittel. *Reviews of Modern Physics*, New York, N. Y., vol. 21, 1949, pp. 541-83.

8. T. O. Paine. AIEE *Special Publication T-91*, "Conference on Magnetism and Magnetic Materials," 1956, pp. 101-17.

9. C. Kittel. *The Physical Review*, New York, N. Y., vol. 70, 1946, pp. 965-71.

10. E. C. Stoner, E. P. Wohlfarth. *Transactions*, Royal Society, London, England, vol. A40, 1948, pp. 599-644.

11. L. Néel. *Comptes Rendus*, Institut de France, Académie des Sciences, Paris, France, vol. 224, 1947, pp. 1550-51.

12. C. Guillaud, *Journal de Physique et le Radium*, vol. 8, 1947, p. 347.

13. I. S. Jacobs, C. P. Bean. *Physical Review*, vol. 100, 1955, pp. 1060-67.

14. T. O. Paine, L. I. Mendelsohn, F. E. Luborsky. *Ibid.*, vol. 100, 1955, pp. 1055-59.

15. L. I. Mendelsohn, F. E. Luborsky, T. O. Paine. *Journal of Applied Physics*, New York, N. Y., vol. 26, 1955, pp. 1274-80.

16. F. E. Luborsky, L. I. Mendelsohn, T. O. Paine. *Ibid.*, vol. 28, 1957, pp. 344-51.

17. W. H. Meiklejohn, C. P. Bean. AIEE *Special Publication T-91*, pp. 16-33.

18. L. Néel. *Cahiers de Physique*, vol. 25, 1944, pp. 1-20.

19. L. Weil. *Comptes Rendus*, vol. 225, 1947, pp. 229-30.

20. C. Guillaud. *Thesis*, Strasbourg, Germany, 1943.

21. C. Guillaud. *U. S. Patent no. 2,576,679*, Nov. 27, 1951.

22. E. Adams, M. W. Hubbard, A. M. Syeles. *Journal of Applied Physics*, vol. 23, 1952, pp. 1207-11.

23. E. Adams. *Reviews of Modern Physics*, vol. 25, 1953, pp. 306-07.

24. B. W. Roberts. *The Physical Review*, vol. 104, 1956, pp. 607-16.

25. J. J. Went, G. W. Rathenau, E. W. Gorter, C. W. VanOosterhout. *Philips Technical Review*, London, England, vol. 13, 1952, p. 194.

26. F. G. Brockman. *Electrical Engineering*, vol. 171, 1952, pp. 644-47.

27. G. W. Rathenau, J. Smit, A. L. Stuijts. *Zeitschrift für Physik*, vol. 133, 1952, pp. 250-60.

28. H Fahlenbrach, W Heister. *Archiv für das Eisenhüttenweisen*, Düsseldorf, Germany, vol. 24, 1953, pp. 523-28.

29. K. J. Sixtus. AIEE *Special Publication T-78*, "Conference on Magnetism and Magnetic Materials," 1955, pp. 142-49.

30. L. Néel. *U. S. Patent no. 2,651,105*, Sept. 1953.

31. Magnetic Alloys and Ferrites (book), M. G. Say, ed. George Newnes, Ltd., London, England, 1954, pp. 144-47.

32. A. D. Franklin, R. B. Campbell, J. Weinman. *Journal of Applied Physics*, vol. 24, 1953, p. 1040.

33. A. H. Geisler. *Transactions*, American Society for Metals, Cleveland, Ohio, vol. 43, 1951, pp. 70-104.

34. E. A. Nesbitt, R. D. Heidenreich. *Journal of Applied Physics*, vol. 23, 1952, pp. 352, 356.

35. E. A. Nesbitt, H. J. Williams, R. M. Bozorth. *Ibid.*, vol. 25, 1954, p. 1014.

36. E. A. Nesbitt, H. J. Williams. *Ibid.*, vol. 26, 1955, p. 1217.

Analog Computers in Propeller Control Design

R. K. FRICK

IN THE PROCESS of designing and developing a dynamic system, provisions should be made for analysis of the performance of the system while it is still in the design stage. One method of analysis is to write the equations of motion of each moving part and then combine these equations in such a manner that a means of solution would be possible. This method is satisfactory if the system has few moving parts and, thereby, does not require many equations to describe its behavior. For a highly complex system, this will prove to be very laborious by longhand methods and should be submitted to machine computation for solution. The motion of the parts of the system may be such that an equation describing the behavior of any one part may be difficult to write unless approximations are made, and may have to be directly simulated by a device which has the proper dynamic characteristics built into it.

The analog computer is especially suited for the analysis of control problems, because it can compute the solution of differential equations and also can simulate nonlinear phenomena directly. There are many forms of analog computers, some of which work by mechanical principles and others which work by electrical principles. The type of computer in widest use is the d-c electronic differential analyzer, which combines the desirable features of the other types, including flexibility, compactness, accuracy, and ease of maintenance.

The computer circuitry is wired so that the circuit equations are the same form as the equations of the system under study. The voltages at various points in the circuit are analogous to the motions or positions of the parts of the system being studied. Because of these analogous voltage operations, the machine is called an analog computer. Another name which is used is simulator, although this term generally is applied to a special-purpose analog computer.

A propeller is a device for converting mechanical shaft power into a propulsive force. This propulsive force is called thrust. Thrust is a function of many variables, among these being the pitch of the propeller blades, the rotational speed of the propeller, and the air density. There are other variables, but these depend on the particular propeller being used. With the variable pitch propeller, a control system must be devised such that proper operating blade angle may be maintained. The type of control system which is most widely used governs the rotational speed of the engine by varying the propeller blade angle. By doing this, the control matches the propeller to the power of the engine.

With such a control system, the propeller governor must be able to sense an off-speed condition and then translate this into terms of blade angle. If an overspeed condition exists, the governor must increase the blade angle which, in turn, will cause the load of the propeller on the engine to increase. This increase in load will cause the system to decelerate until such time as the propeller speed is back down to the desired value. If an overcorrection, or "undershoot" in this case, results, the propeller governor must reverse the process to bring the system back up to the desired rpm value.

In the design of propeller control systems, it is imperative to define the proper values of parameters such as governor sensitivity so that good performance will result. If a propeller governor is too sensitive to changes in rpm, excessive oscillating or "hunting" will result. If the governor and/or control system is too sluggish, excessive excursions in rpm may result. The sensitivity of the control must be a compromise to such an extent that all flight conditions of the aircraft are taken into account. For instance, a given change in propeller blade angle results in a change in load torque larger at high than at low air speeds, and larger at low than at high altitudes.

The fuel control of the engine has certain dynamic properties that must be recognized when designing a propeller control system. Of course, the propeller control will have inherent characteristics of its own which the fuel control designer must appreciate. At any rate, the propeller control and the fuel control must be compatible. There must not be undesirable interactions or conditions under which the propeller control and fuel control have unsatisfactory phase relationships such that each control can oppose the corrections of the other. The parameters which determine proper compatibility of the propeller and engine control systems are such things as time constants of servo systems within the propeller control, backlash in gears, true time lags of components, and dead zones of actuators.

CONCLUSIONS

DYNAMIC PERFORMANCE may be studied by solving the differential equations which describe the system performance. These equations may be solved by longhand methods provided the equations are of low order and are not highly nonlinear. Analog computation methods of analysis are superior to longhand methods because the time and manpower required is less and because fewer approximations are necessary. Solution of the equations results in establishment of criteria for satisfactory transient and steady-state control performance under all expected flight conditions.

Digest of paper 57-501, "The Role of Analog Computers in Propeller Control Design," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Operations Department for presentation at the AIEE East Central and Middle Eastern District Meeting and Air Transportation Conference, Dayton, Ohio, May 7-9, 1957. Scheduled for publication in AIEE *Applications and Industry*, 1957.

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Stability of Aircraft D-C Systems

R. E. THOMAS

IT IS IMPORTANT that the aircraft electric power system designer be provided with techniques for evaluating the effects of inverter loads on the stability of d-c systems. Inverter-induced instability has been a problem for a number of years. In the past, the problem has been resolved by arbitrarily changing the time response of some element of the system. Stability criteria have now been developed on the basis of measurable properties of the system.

A mathematical model of the system has been derived, based upon small motion linearization, and the resulting linear system may be studied by means of frequency response and feedback control theory. The resulting model has a fourth-characteristic equation which may be factored into two underdamped second-order parts. Hence, the open-loop frequency response is characterized by two resonant peaks which actually result from the electromechanical natural frequency of the inverter and the electrical natural frequency of the generator and voltage regulator combination. The application of feedback control theory shows that the fundamental requirement for stability is the separation of these two natural frequencies.

Verification of the mathematical model is obtained by comparing results of laboratory tests of actual equipment with those predicted by the mathematical model. This was done by comparing the computed open-loop frequency response with the closed-loop transient response. This approach was necessary because in the physical system the feedback loop cannot be broken, and hence the frequency response of each individual element must be measured separately. The comparison of these two responses indicates that the mathematical model is satisfactory for predicting the stability of the system and that the open-loop characteristics are not materially changed by closing the loop.

The effect on stability of some of the power transfer properties of the system is obtained by study of the mathematical model. The properties discussed are "bus stiffness," passive loads, and generator compounding. The first two of these properties have a stabilizing effect, whereas the latter is highly destabilizing from the standpoint of system stability with inverter load. In general, the power-transfer properties are adequately resisted by existing performance requirements, and no new limitations on these properties are necessary to insure the stability of a system with inverter load.

Digest of paper 57-478, "The Stability of Aircraft D-C Power Systems with Inverter Loads," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Operations Department for presentation at the AIEE East Central and Middle Eastern District Meeting and Air Transportation Conference, Dayton, Ohio, May 7-9, 1957. Scheduled for publication in AIEE *Applications and Industry*, 1957.

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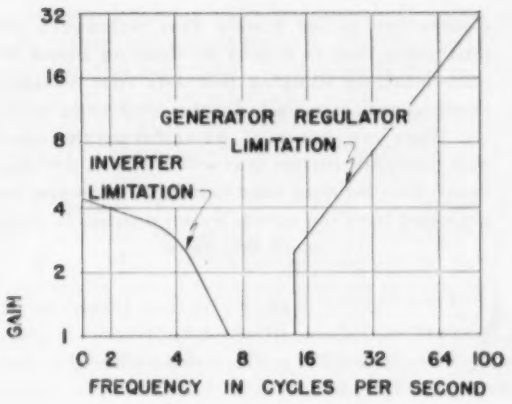

Fig. 1. Signal performance requirements.

However, the signal properties of the system, that is, the requirements which insure the separation of the two natural frequencies, are not currently specified. The signal performance requirements of Fig. 1 are suggested. These requirements are based upon correlation of an analog computer study with laboratory tests. The requirements of Fig. 1 may be listed as follows:

1. The maximum generator–regulator closed-loop gain shall be limited in magnitude according to the frequency at which it occurs by the curve indicated in Fig. 1.
2. The generator–regulator must maintain a gain of unity to at least 14 cycles per second if there is no peak in the frequency response.
3. The maximum normalized inverter input admittance shall be limited in magnitude according to the frequency at which it occurs by the curve indicated in Fig. 1.
4. The normalized inverter input admittance must have reached unity by 14 cycles per second if it does not exhibit any peak.

It must be understood that these requirements are the antithesis of mathematical logic in that they are the sufficient conditions but are not the necessary conditions. That is, the fact that a particular generator–regulator combination does not meet the requirements of Fig. 1 does not necessarily mean that it will be incompatible with inverters which do meet the requirements. It should also be pointed out that if a system designer specifies the range of frequencies in which certain equipment may operate, then steps must be taken to insure that the system does not create any periodic disturbances within this frequency range, for example, those disturbances which might arise as the result of cyclic loads or mechanical vibration.

Some Economic Implications of Automation

J. J. BROWN

Automation is not merely new techniques and machinery, but is a way of thinking about the man–machine complex that has vast economic implications, especially for the electronics industry. There are, however, powerful psychological and economic factors that will brake its development, thus insuring time to adjust. Examples are provided from the author's own practice to document this point.

AT PRESENT, industry is in a transition period between the age in which routine work was done by men, and the age in which such will be done by machines. There is a good deal of confusion about how men fit into this picture, and there is even more confusion about the nature of the required machines themselves. Unless we can eliminate this confusion there is a danger that machines and men will end up locked together in a highly integrated society, with man caught in the works of the machines—powerless either to stop them or to get out. In discussing some economic implications of automation, the aim is to work toward a clearer understanding of where current developments lead.

Among the major hazards of addressing an audience on the economics of automation is the fact that no one agrees on the definition of the two key words. An economist has been defined (perhaps by a cynic), as the analogue of a professor of physiology who is a virgin. On the other hand, the businessman who knows the actual practice of business is likely to be woefully lacking in theory, and in a sense of history. It is obvious that no one knows what our economy is going to do; whether the level of business is going to rise, fall, or remain stable. If any one of us had this priceless bit of information, we could sell the proper industry short, or go long on borrowed money, and soon be millionaires.

The operating level of the economy, however, is crucial because the economic implications of automation are vastly different during booms and depressions. There is a level of automatic operation that is suited to each level of business activity. This level has been defined from one point of view as that which, in a working population of 70 million, provides half a million unemployed at any particular time.

If the associations conjured up by the word "economics" are confused, those of the word "automation" are chaotic. Automation is one of those omnibus words that can mean anything. My definition is not yours, and your definition is not necessarily that of Madison Avenue. Therefore, depending upon how much ground you take in by the definition, automation can be made responsible for everything. A further complicating factor is that the word "automation" has now become either a "rude" or an "okay" word, depending on the particular bill of goods you have to sell. Many union people for their own purposes are in the habit of using automation as a rude word; many management people, again to serve their own private ends, are using automation to describe anything that is wholesome, forward-looking, and embodying the best features of the American Way. These are political uses of the word. Although it is inevitable that words and ideas will be used for political purposes, it is important for anyone who wants to look at the world objectively, to distinguish between political and meaningful uses of words.

Essentially full text of a conference paper presented at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957, at a session sponsored by the AIEE Committee on Management.

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DEFINITION

TO GET AN IDEA of the kinds of things included in my definition of automation, consider a highway that is lighted at night. The cost of electricity is high and, therefore, it is desirable to have the lights on only when required by traffic, and to turn them off as soon as the daylight is sufficiently intense.

At the simplest level, a clock could turn the lights on at a certain hour in the evening, and off again at a certain hour around dawn. A slight improvement on this would be to have, in addition to the daily timing cycle, a cycle which varies the time of switching on and off with the time of year, so that electricity would not be wasted during the long summer evenings. These two belong to the stage of automation where you have control of power by outside means, namely, intermittent programming.

At the next level, you might have both intermittent programming mechanisms and continuous information devices containing the weather report. This would insure that on dark rainy days the continuous controller would override the fixed controller and the lights would go on. Following this line of development a step farther, you could have one of the so-called "thinking machines" which would collate all the foregoing data and much more, and would turn the lights on whenever the summation of the data indicated that extra light was necessary. All these devices, however, no matter how complicated, are still at the simplest stage of automatic control.

Next, you have a photocell placed on the highway

itself. This photocell is capable of seeing how dark it is, and turns on the lights automatically when needed. This device gives the characteristic immediate gain in simplicity which comes with use of feedback.

Now all of these things can be and are properly called automation, but I think it is less confusing if for narrower meanings we use such phases as "high mechanization," and "automatic control."

To me, automation has an inclusive meaning: something like "a way of thinking about the integration of men and machines, with the goal of more efficient production in office and factory."

When the word "automation" is given such an all-inclusive meaning, its implieations obviously extend into every aspect of economic life. The effects of automation really are just beginning to appear. However, these effects already have been far reaching.

The overriding implication of automation is its effect on the relative size and importance of industries. The electronics industry, which is seen as the keynote of automation, will rapidly develop into the largest single industry. This process is now well under way. Between 1952 and 1956, the gross volume of sales of electronic computing equipment alone rose from near zero to $300 million. At any particular time, one or more segments of the electronics industry are tending to follow exponential growth curves. Radios and television sets, for example, increased in volume from $186 million to $810 million between 1939 and 1947; in the same period, components for communications and industrial electronic controls jumped from $75 million to $348 million. According to a recent study by the editors of *Fortune* magazine, electronics as a whole is an $11.5 billion industry and is growing at the rate of $50 million each year.

This spectacular growth is both a cause and an effect of increased automation.

The basic technical element required for the widespread application of automation is the science of electronics. The electronic art must underlie the economic organization of automation. The organization of automatic machines, while possible by mechanical means, does not lie within the realm of economic practicalitf or most areas of manufacturing. Electronics is the common denominator which binds all the diverse technical elements that must be wedded to achieve truly automatic production and distribution of goods and services.

TWO EXAMPLES

FROM THE VAST ARRAY of specific economic implications of automation two examples are chosen. The first has to do with an effect of self-controlled machine tools on plant decentralization. The mass production of operations can be achieved by recording the motions of a skilled machinist, by coding a record, or by recording instructions in digital form. One of the earliest forms of machine control was AMCRO, patented by Leaver and Mounce in 1949.

This machine permits an ordinary lathe, milling machine, or other type of machine tool to perform a wide variety of complex operations, automatically controlled from a record. In operation, a skilled workman makes a sample part. While he is working, information relating to tool position, speed and the like is recorded. At the end of the series of operations, the machine is loaded with fresh stock, the record switched to playback, and a new part, which is a faithful reproduction of the sample, will be turned out automatically. The record can be played over and over again, so that parts will be made as long as the machine is fed with stock.

Inasmuch as the record may be remote from the machine, and as many machines as necessary may be connected in parallel, such systems are ideal for plant decentralization. Thus in the future, engineering and design staffs may be located at headquarters offices in large cities, while actual manufacturing is done in semiautomatic plants scattered around the country. It is not difficult to see that added impetus to decentralization will have far-reaching consequences in such fields as real estate, personnel recruitment, and transportation.

A second point that should be mentioned briefly, simply as an illustration, is the effect of function vs product orientation on design. For some years, I have been arguing that machines should be designed in terms of the functions they perform rather than in terms of the product they make. There are indications now that this notion is beginning to find some adherents. If this ever becomes a basic tenet of designers (and I think it will), two effects are immediately discernible. One is the immediate simplification of machine tools, because functions are always simpler than products; another is the effect on the products themselves. Today's products are all designed for manufacture on product-oriented machinery, and for hand assembly. It is not surprising therefore to find that such designs do not lend themselves to automatic manufacture. Automation leads to basic redesign of products and this, in turn, leads to an array of economic consequences ranging from the trivial to the catastrophic. Economic consequences of any new technology are like neutrons triggering successive fissions in the nucleus of the atom. They go on until all available material has been affected. Hence, the new kind of design thinking, which will be one result of automation, will lead to economic changes of far-reaching significance.

GOALS OF AUTOMATION

TODAY, CLEARLY ENUNCIATED PRINCIPLES and aims of automation are at least at the discussion stage, and we have some practical rules of thumb for achieving these aims.

At the level of pure theory of automation (as distinguished from how automatic control of processes often works out in practice), I cannot do better than go back to an article I wrote in collaboration with E. W. Leaver for *Fortune* magazine in 1946. Here, we set out some general theory about the kinds of jobs in our society that could best be done by machines. These general ideas were set down in more specific terms in an article

in *Harpers* in 1950. I think I have read every major article and every book published on automation since the subject became popular. But these basic principles, as laid down in the *Harpers* article still apply:

1. Machines should replace men wherever possible. This means simply that the immense human labor that has gone into new technology should not be wasted.

2. Men should not be used for routine operations, if machines can do the work. That is, men should not be wasted, because the human mind and hand together make a unique combination that is capable of high productivity. This generalization applies even in the face of economic factors. That is, even if the machine is costly and complicated, and the job could easily be done by men working for low wages, machines should be used. Although the short-term cost of such a principle is high, over the longer term it pays off in two ways. First, it develops a higher level of technology. A complicated machine never materializes out of thin air, but requires a long chain of technicians and engineers developing and manufacturing its components. Second, the kind of work a machine can do is not usually the kind that brings out the best potentialities of human beings. This leads to a third general principle, namely:

3. The automaticity of men should be discouraged. All work is done by a mixture of men and machines. The tendency during the 18th Century was to degrade men to the status of machine tenders. It was their job to keep up with the machine no matter how fast it operated or how automatic its action. Some people think that this lowered status of the man in the man–machine complex is a root cause of many of the domestic and international crises afflicting society today. Men who spend their working lives chained to a machine without exercise of their intelligence in time become incapable of making the decisions required of citizens.

4. A corollary to the foregoing is that the automaticity of machines should be encouraged. In a world where it is such fun to make a device more elegant, and where one of the chief drives of engineers is to improve a machine for its own sake, this is not a problem. Even at the level of unskilled help in a factory, there seems to be a strong drive to improve machinery and process. This was demonstrated by the outstanding success of employee suggestions utilized during the war.

What the foregoing four principles boil down to is that men must always be ancillary to machines, that is, men should watch machines do the work and, in some cases, be on hand to correct the machine's action as required, but they should never be in series with the machine. The combination of machines and men in series makes man a slave to the machine, because he has to keep up with it. In such circumstances, the unique adaptability and creativity of men is lost.

These four principles are all very well as theory, but in order for them to have any impact there must be some way of putting them into practice. Most of the machines we have today were designed with different ends in view. What is needed is a set of design principles geared to the goals outlined. These, as we saw them in 1950, and essentially as we see them today, are functionality, unitization, and universality.

1. *Functionality.* Machines must be designed in terms of what they do, not in terms of what they make. This means that instead of building a machine called a fuel pump lower casting boss broach (which is a special purpose machine if I ever heard of one), we look at the operation to be performed and develop a machine capable of removing the right amount of metal in the right places.

2. *Unitization.* Machines must be unitized by some method, preferably through the common denominator of electronics. The individual components making up a production machine should be single-function units, capable of grasping, boring, feeling, and comparing. These units should be put together temporarily in such a way that they make one product, and then, when assembled in a different way, can make a different product. By far the best way to obtain the collation and control of such units is by means of electronics. Electronic units are standardized, and lend themselves to high-speed operations. Moreover, we know more about how electronic and electric systems operate than about almost any other type of system. It is amusing to recall that only 20 years ago the text books were drawing on the science of hydraulics for analogies to show how electric systems worked. Now we use electric circuit theory to teach not only hydraulics, but even economics.

3. *Adaptability.* Because both machine tools and electronic control units are expensive, it is better if they can be used to make a variety of products. A transfer machine is an ingenious device, but because it is both expensive and incapable of making a wide range of products, it can be used only by large mass-production factories. What is needed is small operating and control units that are adaptable, so that they can be plugged into each other in various ways to make different products.

These general principles still hold today. In automation, nothing has changed since 1950 except the level of public awareness. This is not to say that public awareness of automation is not important. It is, in fact, crucial. Until management, labor and the general public have been sufficiently educated through exposure, there is no use discussing automation in either theory or practice. But this job has now been done—some think not wisely but too well. What needs to be done today is the painstaking accumulation of specific cases where the principles of automatic control outlined have been applied in business and industry. Such cases contain important lessons to guide future activities in this field.

The economic implications of automation have been discussed at length, in general terms, in the last few years. Today there are whole books devoted to the subject. It is my purpose to avoid as far as possible any general discussion and to direct attention to specific cases from my own practice which point up certain lessons.

The first one chosen is a large mass-production industry, a company with an excellent cash position, and which is in the 50% tax bracket, and therefore in a position to afford almost any capital expense. Another is from a medium-to-small metal-working company where money is less freely available for capital expenses, and where income is generated somewhat less automatically than in the large corporation. A third example is from a very small, very backward industry with a tradition of hand-craftsmanship. The final example is a medium-size mass-production industry where they pay very low rates for labor.

Each one of these companies presents a unique problem. A basic point I want to make is that economic implications of automation are not something you can generalize about on a theoretical or even on a practical level. What these cases demonstrate is that the same degrees of automatic control, introduced into two companies of different size or in different industries, will generate quite different economic results.

Although the economic and social effects of automation will be far reaching, it is felt that the economic factors and human nature will insure that any changes will come slowly. There will be plenty of time to adjust thinking to automation.

ECONOMIC BRAKES ON AUTOMATIC CONTROL

AT FIRST GLANCE, the question "Is automation worth what it costs?" looks simple. All that must be done is to determine from wage rates and job cards how much the job is costing by methods currently in use, and then set a reasonable pay-out period for that industry. For example, if the new machine costs $10,000 and results in net savings of labor and material of $800 a month, the pay-out period would be about a year.

In specific cases, however, the bare economic decision turns out to be much less simple. In the small plant, the basic problem of automation turns out to be something that has nothing to do with manufacturing processes or techniques. It is simply cost accounting. Without adequate knowledge of the company's costs under its present system of manufacturing, you have no base from which to work. At one time, I labored under the delusion that a company which did not know its costs would soon go bankrupt, that there was a process of natural selection operating which would insure that only efficient producers would survive. This is far from the case. Lots of plants make and sell a product and have no idea whether they are selling it for more than its cost or less. This is particularly true of old established businesses with extensive lines. What they lose on the eggs they make up on the bananas, or, as often as not, they are operating on capital. But this state of affairs makes for an impossible situation when you introduce more automatic methods of making a particular product.

Even the best cost accounting systems leave much to be desired, and most companies do not even have an elementary system. In the plant, a demonstration of a new technique may be an unqualified success. But in the office, you come up immediately against the fact that the company has no idea of the cost of its present system. Hence, you cannot demonstrate how soon a new machine will pay for itself in labor and material savings.

To sum up, one lesson which has been learned is that in a small company, production cost-control is crucial. Today, when we go into a company of this size we find out first what kind of cost control system is in operation, and whether it is reasonably accurate. If no attempt is made at cost control, the first and only suggestion to the client is that such a system be installed. Only after this is done, do we feel we have an adequate base for moving into other areas.

Another economic problem is to determine a reasonable pay-out period. In some industries, if a machine pays for itself in five years it should be installed; in others, where the rate of technological change is rapid, a three- to six-month pay-out period might be too long.

A recent experience in a medium-size mass production industry has pointed up another basic economic problem. This is the question of what wage rates to use in making feasibility studies. The average industrial weekly wage in Canada, as published by the Dominion Bureau of Statistics, is something like $55. But, if feasibility studies for the application of automatic machinery to a particular industry are based on this figure, they are probably wrong. This is because the $55 figure is a national average and, as such, is made up of a wide range of weekly rates, perhaps from $20 to over $100. It is obvious that if a company is paying the particular help that the machine eliminates, $30 a week rather than $60, the pay-out period of the machine will be doubled. Certain mass-production industries that seem at first glance to be ideal application grounds for automation turn out, on further study, to be very difficult. This is because, although the manufacturing operations are repetitive, at current wage levels in that industry people can still do the job cheaper than machines.

The reason for this is not far to seek. Automatic machines consist of many carefully articulated mechanical and electronic components. Tolerances are close, design standards high. Often each machine is different, or at least a basic machine has been more or less modified in order to make it fit a particular factory's special requirements. For all these reasons, automatic production machinery is expensive. In a society in which people are plentiful, the cheap factory hand will always pose the threat of competition to the machine.

In the particular company we studied, management was able to hire people for $30 a week. These wage rates, weighed against today's machine costs, made automatic production economically out of the question. It is felt that this management is making a mistake, and that the longer term will prove it, but the short-term economic facts definitely are on their side.

PSYCHOLOGICAL AND POLITICAL PROBLEMS

IN ADDITION to all the economic brakes on automation, we have even more important roadblocks of a psychological and political nature. It has been said that

any process can be made automatic, if cost is no object. This is true, but beyond the question of cost is the question of whether or not the executives of a company really want to see a change. This is the basic problem we run up against in large corporations. At the simplest level, the question is, Is management ready to think about automatic production from a technical point of view? Management people are for the most part unfamiliar with the technology of automatic control, hence approach it very gingerly.

At a deeper level, we have to ask whether management is now amenable to contemplating the changes in company organization and status systems that will probably become necessary when automation is introduced in either plant or office. These are questions of great gravity, particularly to the individuals whose status is changed. Such questions as the effect of automation on interdepartmental relations, on departmental spheres of influence, etc., must be very carefully investigated before the machines are installed.

Tied in with all of these problems is the question of vested interest. Management people normally have a vested interest in the status quo. Automation, even in its mildest form, is basically a disruption of the status quo. At whatever level in the company, each man prides himself on the complexity of his particular job. Most company presidents pride themselves on the complexity of their business. They say "this business is different. It's really too complicated for any outsider to understand." A person who comes in from outside with the avowed purpose of simplifying materials flow and of rationalizing the production process, poses a serious threat to the vested interests of management people.

This threat is no less real to the union executive. He has spent many years building up a seniority system, grievance handling procedures, and other union services. Now, simply by the introduction of changed methods of materials handling, or different means of parts assembly, automation has destroyed certain job classifications and blurred the lines of seniority. To workman and manager alike, the threat of automation is that it is disruptive of the status quo.

The *locus classicus* of management and union opposition to change has been the large corporation, but this opposition is frequently encountered in small, tradition-oriented companies as well. It must be remembered that in a basically hand-powered industry, the problem of introducing modern technology, let alone automatic control, reduces itself to the problem of teaching before an unsophisticated audience. This, even under ideal circumstances, takes plenty of time.

A basic point I want to make in this paper is this: The major roadblock in the road to advanced automation is simply human nature—man's basic hatred of change. Fundamental human conservatism, reinforced by the built-in financial conservatism of the business world, is a massive obstacle to all the kinds of rational production planning, automatic control of process, and automatic assembly, that are technically feasible today. The weapons we have for chipping away at this roadblock are really rather puny. They consist of education—always a long-term rather than a short-term process—and economic pressures which are ordinarily so diffuse that it is difficult to put your finger on one factor and say that it is uniquely responsible. It is true that a manufacturer wants to make a profit, but it is not true that you can isolate any one factor in his operation (such as obsolete machinery) and say that this is the sole cause of his failure to realize the profit.

CONCLUSION

For these and other reasons, I am not much concerned over the horrendous effects of increased automation that we read about with increasing frequency in the popular press. Nobody knows what is going to happen. Of great concern is the fact that very few people are making careful studies of actual cases where various degrees of automatic control are being applied in business and industry. Until such time that there is a large body of case material, collected by people who know what to look for, we shall lack a firm base for rational progress in automation. This material has then to be sifted by scholars to bring out the lessons it contains. Until all this has been done, it will be impossible to make any firmly based statements about the economic effects of automation. Thus, the first step is painstaking collection of case material from all industry, large and small. Every engineer can help to build up the orderly literature required. He can perform an important service by collecting case material, and by constantly developing the trained observation that makes such material useful. This literature, to which thousands of engineers will have made their contribution, will in time provide a scientific basis for management decisions.

Atomic Power Spindle

A steam turbine spindle which has been manufactured for the world's first nuclear power plant in Shippingport, Pa., by the Westinghouse Electric Corporation's Steam Division in Lester, Pa., has already been delivered to its Shippingport site.

Because of the turbine's large size, it is being shipped in sections for reassembly at Shippingport. When assembled, the 100,000-kw steam turbine will weigh approximately 1,300,000 pounds and measure nearly 81 feet in length. The unit will be capable of handling 1,400,000 pounds of steam per hour. By means of a heat exchanger, water under high pressure from the reactor will give off heat to create steam which will drive the 1,800-rpm turbine.

Westinghouse is developing and building the nuclear reactor for the atomic power station under contract with the U. S. Atomic Energy Commission. Duquesne Light Company of Pittsburgh is financing and building the electric generating portion of the plant and will operate the power plant upon completion late this year.

Integration of Hydro and Thermal Power Resources

M. M. WILLIAMS

THE PROVINCE OF ALBERTA, with a population of 1,123,000 living in an area of some 110,000 square miles out of a total area of 255,285 square miles, requires an extensive network of transmission lines to supply the electric power needs of its people. At the end of 1956, there were 36,097 miles of 2,300- to 138,000-volt transmission lines operated in the Province.

Feeding power into this transmission network were municipally owned plants with a capacity of 183,089 kw and privately owned plants with a capacity of 390,075 kw, making a total capacity of 573,164 kw.

This network of high-voltage transmission lines facilitates the integration of substantial hydroelectric power resources and thermal power, based upon large reserves of coal and natural gas. It is estimated that there remains in the Province a hydroelectric power potential of over 1.5 million kw within economic transmission range of the existing populated area. By December 31, 1956, the remaining marketable reserves of natural gas in Alberta were 17.4 trillion cubic feet and the total minable coal was estimated at 48 billion tons, representing 48% of Canada's total reserves.

Calgary Power, Ltd., which supplies two thirds of the electric energy requirements in Alberta, is well situated to develop both thermal and hydroelectric plants. Its high-voltage transmission lines serve an area representing 60% of the Province's populated area. Within this area are many of the Province's major oil and gas fields and much of the minable coal reserves. The company's lines are also within economic transmission range of over 1.5 million kw in hydroelectric power potential.

Prior to 1956, the company supplied the bulk of its load from hydroelectric plants on the Bow River west of Calgary. By December 31, 1955, thermal plants only represented 10% of the company's generating capability of 247,000 kw. By the end of 1960, however, thermal plants will represent 49% of its generating capability of 632,000 kw.

In October 1956, the 66,000-kw Wabamun Steam-Electric Plant became the first major thermal unit in the company's system. This plant is located on the shores of Lake Wabamun, 42 miles west of Edmonton. Initially it will be fired with natural gas under a 10-year contract, at a price of 10½ cents per million Btu (British thermal units). However, it was constructed to accommodate coal handling equipment, should it become more economical to burn coal than natural gas. The particular location for the plant site was chosen because of the large body of cooling water in Lake Wabamun, the nearby 80 million ton reserve of strippable coal, and the proximity of the site to the rapidly growing electric load in the Edmonton area.

Thermal plants such as Wabamun were not a major economic factor in the company's system until the rapid growth in its load occurred following the discovery of the Leduc oil field in 1947. Prior to this time, the load center was in the vicinity of Calgary and adjacent to hydroelectric sites on the Bow River. By 1956, however, the load had increased three times over 1947—the highest rate of growth being in the Edmonton area. During this period, the company's base load grew to the point where relatively large steam–electric units such as Wabamun could be operated at a high load factor.

The economics of base-load steam–electric plants are greatly improved as the size of the units are increased. Larger units have the advantages of lower capital cost per kilowatt, high efficiency, and lower operating cost per kilowatt-hour.

With fuel at 10½ cents per million Btu, it is estimated that base-load energy can be produced at Wabamun more economically than that possible from remaining hydroelectric sites in the Province. The Wabamun Plant was therefore designed for base-load operation.

Increments of capacity added to the company's hydroelectric plants normally cost less than that for thermal–electric plants as the additional hydroelectric capacity is not materially affected by the cost of dams, spillways, reservoir clearing, access roads, and auxiliary powerhouse equipment such as the overhead crane and a portion of the powerhouse superstructure. Advantage of this low incremental cost can be taken in hydroelectric plants with associated storage reservoirs or large head ponds as they can be operated at a very high rate over peak-load periods and can, therefore, effectively use the full capacity of the extended plant.

In addition to lower cost, hydroelectric plants have other advantages over thermal plants for peak-load operation. They can be brought in on the line in much shorter time and can follow more effectively the fluctuations in load during peak-load periods. They can also be started and stopped as frequently as required with little loss in efficiency.

In Alberta, where adequate thermal and hydroelectric power resources are available, the minimum production costs are obtained when the thermal plants are operated on base load and hydroelectric plants on peak load. Calgary Power at present is actively planning its production facilities to integrate these two power resources. During the next five years, it has scheduled for completion 98,000 kw in hydroelectric capacity and 216,000 kw in thermal capacity.

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Orderly Creative Inventing

W. H. MIDDENDORF
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G. T. BROWN, JR.

A method of creative inventing is described that, unlike other systems, is more applicable to individual than to group effort. The heart of this system is the process of abstracting from each subunit of the proposed device those properties and characteristics that will help the would-be inventor visualize the functional relationship of one subunit to another.

DURING THE LAST DECADE there has been a considerable increase in effort by engineering and research administrators to understand and foster creative thinking. The content of articles concerned with invention has varied. Some have sought to show the urgent need for continued inventiveness[1] others have indicated the basic faculties which are important to the creative process,[2] and still others have described the stages of the inventive process.[3] The romantic theory that an invention will appear in full bloom without conscious effort on the part of the gifted inventor has been deprecated.[4] Methods of attacking problems which require creative thinking have been developed.[5,6] A basic similarity among the various plans, as indicated by Table I is apparent. These have been demonstrated to be worthwhile; but worthy of special consideration is the fact that essentially the same thing is said in different ways. This, in itself, is useful inasmuch as some persons respond to one presentation whereas other persons respond better to a different presentation.

LIMITATIONS OF CURRENT METHODS

As one considers these plans, certain observations can be made as to their use. The references indicate that plans to engender creativity have been developed primarily for group participation. Disregarding the fact that some controversy exists as to the real value of these so-called brainstorming[6] sessions, an impasse is encountered by the many smaller organizations which do not have the personnel to participate in the game. For these situations another approach, more applicable to individual effort is necessary.

Furthermore, the general terms used to describe the steps of the various plans reveal that they were designed to fit all types of problems that must be solved by uncharted paths. This may be a disadvantage. Problems that involve invention of a new device or process are quite different from those encountered in sales, production, administration, etc. Among these differences are: (1) physical problems that lend themselves to greater subdivision because there is less unanticipated interaction between parts of the whole; (2) physical problems that need to satisfy the exact laws of nature rather than the less accurately known principles of business or human relations; and (3) problems of definitions and semantics that are greatly reduced in physical problems.

These considerations lead one to believe that a more effective method can be developed to apply to problems involving the invention of a device or process. The well-developed methods of analysis support this contention. In analysis, it is often true that restricting the area of application permits further development and increases the usefulness of a given method. For example, steady-state circuit analysis is much more useful for problems within its scope than the general approach by field theory.[7] The plans summarized in Table I also support the contention that they might be improved by restricting the area of application, inasmuch as each plan calls for a precise definition of the problem. If the method for creative thinking is to apply to the invention of a device or process, a precise definition of the problem should consider this restriction as the plan is evolved.

DESCRIPTION OF NEW METHOD

It is the object of this article, therefore, to describe a method for primordial synthesis of a device or process that is well adapted to individual effort and that generally lends itself to a variety of possible problem solutions some of which may be useful and novel. It is the further purpose of this article to stimulate application of this line of reasoning to other areas where techniques for creative thinking can gain by specialization.

Some of the steps of the proposed method are the same as those of the methods previously discussed. Continuing to learn from methods of analysis however, a transformation step is introduced which forces the would-be inventor to think in terms of what he wants to accomplish rather than in ways in which similar devices have been made.

One of the important aspects of the technique proposed is the mechanics of execution. The clear definitions and large memory storage required by orderly creative inventing demand that the would-be inventor put his thoughts in well-written concise statements. Failure to do this generally results in inefficient rambling of the mind and a tendency to slip into a state of low mental activity. On the other hand, the mere act of

A special article recommended for publication by the AIEE Committee on Educational Publications.

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writing one's thoughts in good English disciplines the mind and keeps it active. As the steps of the plan for orderly creative inventing unfold, therefore, one should understand that extensive use of paper and pencil are deemed a very necessary part of every step.

The first step in the proposed plan requires a definition of the problem. At the beginning this will usually be vague. Perhaps a number of tentative definitions may result or only the area of endeavor be defined. As the solution develops, however, the inventor should return to the definition of the problem to improve and restrict it. As will be shown, this method results in so many solutions that it is wise to reduce the number by imposing any restrictions which are true and absolute as soon as they are apparent. On the other hand, extreme care should be exercised not to include restrictions that are based on prejudice, prior art, or whim.

As the second step, the would-be inventor must gather facts. Invention necessarily requires the availability of a wealth of information. The greater the storehouse of knowledge the more likely the success. For new devices or processes, a typical as well as very important source of information is the status of prior art as is described in related patents. The point of view that study of previous patents can result in an unintentional mimicking of the devices already patented is not without merit. However, the avoidance of the knowledge contained in this most valuable record of prior art cannot be justified as a reasonable solution to the problem. As one works in a given field, he is certain to learn something of the previous practice and such a superficial knowledge increases the probability that the inventions he makes will have been anticipated. More wholesome advice is to become so expert in the previous art that one can recognize imitation when it occurs. Then, the inventor needs only to acquire the faculty of transcending the limitations suggested by the previous designs with which he is familiar. This point of view was held by Edison whose biographer writes "His method of attacking an inventive problem of major importance was always the same. He would attempt nothing until he had a clear comprehension of the existing state of the art . . ."[8]

A full storehouse of knowledge is a necessary but not a sufficient condition for invention. To this, one must add an organized method of attack which will allow him to call upon this storehouse for ideas in such a form that they are simple enough to comprehend and visualize. An ability to visualize reality is recognized as one of the most important facilities the inventor must possess.[4] Those who are more gifted in this respect can comprehend systems more complex than the systems held in mental image by the less gifted, but each has his limitations. One may compensate for his limited ability to visualize a complete mechanism or process by following the next step.

As the third step, it is suggested that the would-be inventor must develop the habit of reducing a given problem to a number of smaller problems, each being easier to comprehend and visualize as reality. This is the same technique as is generally taught in college courses on analysis. Unfortunately, the transfer of technique from one area of mental activity to another is not automatic.[9]

Table I. A Comparison of Several Creativity Procedures[6]

John Dewey	General Electric	Alex Osborn
1. Determine real problem	1. Recognize the problem 2. Define the problem	1. Orient—point up problem
2. Gather all facts	3. Search for method of solution	2. Prepare — gather pertinent data
3. Analyze the problem—obstacles to be overcome	4. Evaluate methods	3. Analyze—break down relevant material
4. List possible solutions for overcoming obstacles	5. Select best method	4. Hypothesize — pile up alternatives by way of ideas (brainstorm)
	6. Make preliminary design	5. Incubate—let up to invite illumination
	7. Test and evaluate	6. Synthesize — put the pieces together
5. Develop plan of action	8. Follow through	7. Verify—judge resultant idea

Applying step three of this orderly creative process to the invention of a circuit breaker, for example, one can visualize the automatic operating mechanism, the manual operating means, the arc snuffing unit, and the current responsive means as being separable but interrelated systems. In this device, as in most others, one of the divisions (the operating mechanism) will influence the design of the other units to the greatest extent and should be considered first. Each of these units can be further divided into still simpler functional elements and, with each separation, the ability to visualize the parts fully is increased.

ESSENCE OF PLAN

THE FOURTH STEP is the heart of this plan for orderly creative inventing. It can be inferred from the analytical processes. In problems of analysis, constraints are most welcome inasmuch as they help determine the one answer that is usually sought. In problems of synthesis, however, there is no single answer. Indeed, the more answers obtained, the more likely it becomes that one will find a solution which will be useful and novel. Thus, the constraints, which for problems of synthesis are the limitations imposed on each subunit, should be kept to a minimum.

To facilitate the assignment of the fewest limitations to each element, the problem, already simplified by division, must be transformed into a listing of the physical states, properties, or functions of the subunits taken one at a time. These characteristics are called the parameters because they are the constants which determine the variables of the system. In determining the parameters, the would-be inventor changes perspective from the particular physical embodiments with which he is familiar to the minimum number of functional attributes each unit must possess. The tendency to describe by adjectives, or visualize by pictures, rather than to describe or visualize by the functional relationship of one part to another makes this method one that requires conscious effort and profound concentration. This process usually is aided by jogging the mind with such questions as:

What must this element accomplish?
How or where must this member communicate with its environment?
What properties must the material possess?

Returning to the example of the circuit breaker, the parameters of the operating mechanism which has previously been described as the main subunit may be stated as: (1) a current path, (2) force to close the contacts, and (3) reversal of force to separate the contacts upon overload.

This transformation from a physical embodiment to a device or process described only by functional requirements or properties is the most important step in the process. It may be performed, however, by working from similar devices or methods as determined by prior art, if one is careful to include only the functional requirements that are necessary. If this is done skillfully, there is little danger of mimicking the devices or processes which served as models since the particular physical embodiments are lost in the transformation.

After each unit has been completely described by the parameters, as many alternative methods as may be possible for providing these basic requirements must be determined. This is the fifth step. It is the reverse of the fourth, because now the necessary properties and functions are transformed back to many physical embodiments. At this point, the would-be inventor must show originality. This approach cannot eliminate the need for this fundamental part of invention. The point is, however, that the subunits under consideration are now simplified sufficiently so that they can readily be described with regard to functional requirements, and ways of satisfying these requirements can be readily visualized in reality. Also, because only the most basic requirements have been set down, the inventor is not prone to restrict his solutions to those in his own prior experience or those of the prior art.

The reduction in complexity effected prior to this step makes originality in solution of the many simpler problems probable. Perhaps the greatest aid to originality is a change in the mode of stimulation. After a period with pencil and sketch pad, it will usually be found most rewarding to make a change to working with a model. Often, it may be necessary to work with a primitive device which has obvious defects. Nonetheless, the benefits associated with a change in stimulation will be realized.

The sixth step is simply a discerning selection from the many solutions that have been generated. The variation of the solutions to each of the problems formed by subdividing the original problem are now available to reassemble in many different combinations. One should not expect all the combinations to be usable, but many are apt to be; and some may be both usable and novel.

This method for orderly creative inventing permits complete coverage of all the possibilities which are compatible with the limitations as expressed by the parameters. Whitehead[10] has shown that the number of embodiments possible when considering the design of one subunit of a measuring microscope to be over 1,000. As the other subunits are considered, the total combinations possible increase rapidly. To assure oneself that all combinations are considered, computers may be used to describe the combinations. Upon study of the combinations made by a computer, one will certainly find some which are ridiculous. If the characteristics of the ridiculous combinations are used to cull the rejected designs, the inventor need not study each entry on the original list. Repeated application of rejection by the computer can be used to reduce the list of inventions to a manageable size.

APPLICATION OF METHOD

AN EXAMPLE of the application of the steps to the invention of a device has been given as the steps were explained. Applications of this method to a well-known process should serve to further inculcate the technique. Suppose a plant was spray-painting bedsprings automatically and that objectionable drips and tear drops were being formed.[5] The engineer might proceed as follows:

Step 1. Problem: Provide paint covering of constant thickness.
Step 2. Gather information: Suppose a search of patent files and literature did not yield a solution. This of course is still available to guide the engineer in his deliberations.
Step 3. Divide the problem: The process involves three major parts, as follows:

1. The paint.
2. The applicator (limited to spray gun for this example).
3. The receiver (limited to bedsprings for this example).

Step 4. Describe by parameters, and
Step 5. Determine variations of the parameters.

Subunit	*Parameter*	*Variation*		
1. Paint	Viscosity	High	Medium	Low
	Homogeneity	Small pigment	Medium pigment	Large pigment
	Solvency	Water	Oil	Other
	Surface tension	High	Medium	Low
	Temperature	High	Ambient	Low
2. Applicator (spray gun)	Disperse	Small drops	Medium drops	Large drops
	Direct	Narrow beam	Medium beam	Wide beam
	Propel	Low speed	Medium speed	High speed
3. Receiver (bedspring)	Material	Steel	Bronze	Other
	Surface condition	As produced	Cleaned	Precoated
	Temperature	Cooled	Ambient	Heated
	Movement	At rest	Rotation	Vibration
	Orientation	Vertical	Horizontal	Angular

In carrying out step 4, all the parameters which have any possibility of bearing upon the situation should be included. Perhaps some, which the reader knows are unnecessary, are included and others which are important are not there. Step 2, the gathering of information, was not actually fulfilled in working this example. With more preparation this defect would not occur.

Step 5 normally calls for a transformation from the parameters to means of providing these parameters in various ways and to varying degrees. A list of the variation of the parameters has been used here as being more meaningful for this simple example.

There are many combinations possible from this list. As some are evaluated by study or by test, the engineer may find that the paint distribution is not sensitive to one or more of the variables. Variation of pigment size, for example, may be found to have no possible effect. Once this is proved, the number of combinations should be reduced. Indeed, as the engineer scans the list, he will find some combinations most likely to be valuable. This is the last step.

Step 6. A discerning selection of solutions: As the engineer studies this list, several combinations are more attractive than others. One group includes applying paint at an elevated temperature to precooled bed springs. This may not do the job but it probably would not be considered if it were not for the orderly approach used. Other groups of solutions include rotation or vibration. The former suggests a centrifuge but may not be practical for something as large as a bedspring. The latter, vibration, is particularly intriguing because the unit in question is made of springs. If the vibration is violent enough, the excess paint will surely be removed. The invention of a device used to induce vibration can properly be the subject of another application of this method for orderly creative inventing.

In practice, this method has been applied more often to the invention of devices than to the invention of processes. Its success is indicated by the fact that the authors have more than 25 patents issued and pending. Moreover, with suitable modification, the technique has been used with success in developing new equations and methods of computation.[11]

This method was introduced recently to one group of students at the University of Cincinnati. They were allowed to work for two 4-hour periods on a problem of their choice. Several chose problems the solution of which would have required information not available to the students. However, of the 13 participating, 3 developed sketches of devices that deserved further consideration. It was not possible to judge whether the devices were patentable, inasmuch as the time available did not permit a study of the prior art. As far as students or instructor know, however, the devices are both useful and novel.

SUMMARY

This article has shown the need for an orderly creative process, applicable by individual effort, to the seeking of an invention of a process or device. The method proposed is composed of six steps. It allows the would-be inventor to start by considering the devices or processes of prior art; then, by a transformation to a description of functional requirements and a counter-transformation to physical embodiments, many possible devices or processes are generated. Modern computers permit such printing speeds that every combination may be described in computer language, the list reduced as undesirable groups of combinations are discovered, and the remaining most feasible combinations made available for considered, individual judgment.

REFERENCES

1. Stimulating Invention by Engineers, R. H. MacCutcheon. *Machine Design*, Cleveland, Ohio, vol. 26, Jan. 1954, p. 125.
2. How Collective Genius Contributes to Industrial Progress, K. K. Paluev. *General Electric Review*, Schenectady, N. Y., vol. 44, May 1941, pp. 254-261.
3. Developing Creative Engineers, J. F. Young. *Mechanical Engineering*, New York, N. Y., vol. 67, 1945, pp. 843-48.
4. Deliberate Creativeness in Science and Engineering, Maurice Nelles, *Chemical and Engineering News*, vol. 31, Apr. 13, 1953, pp. 1520-23.
5. How To Make Good Ideas Come Easy, L. R. Bittel, *Factory Management and Maintenance*, vol. 114, March 1956, pp. 84-90.
6. Brainstorming: Cure or Curse?, *Business Week*, New York, N. Y., Dec. 29, 1956, pp. 44-8.
7. Analysis of Electric Circuits (book), W. H. Middendorf, John Wiley & Sons, 1956, Art. 1.02.
8. Thomas A. Edison, Inventor, *Electrical Engineering*, vol. 66, Feb. 1947, p. 113.
9. General Psychology (book), J. P. Guilford, D. Van Nostrand Co., Inc., Princeton, N. J., 1938, p. 462.
10. Instruments and Accurate Mechanisms (book), T. N. Whitehead, Dover Publications, Inc., 1954, p. 230.
11. Graphical Determination of the Fourier Series Coefficients, W. H. Middendorf, AIEE *Transactions*, pt. I, Sept. 1956, pp. 478-82.

"Auto-Sembly" Technique

Two engineers employed at the U. S. Army Signal Engineering Laboratories, Fort Monmouth, N.J., received a record joint cash award of $10,000 in ceremonies at the Pentagon last Wednesday.

The presentation was made by Secretary of the Army W. M. Brucker to S. F. Danko of Neptune, N.J., and Moe Abramson of Long Branch, N.J. The sum represented the highest amount ever presented to Department of the Army civilian employees.

Mr. Danko and Mr. Abramson developed a process of automation known as "Auto-Sembly" which, it is estimated, will save the Government $4,200,000 in the first year of operation.

"Auto-Sembly" simplifies construction of electronic and electrical equipment which constitutes a sizable proportion of essential weapons, communications and control devices used by the Armed Forces.

The invention replaces the former slow, time consuming, skilled labor, individual soldering technique. "Auto-Sembly" embodies the use of wire patterns printed upon a plastic base perforated to receive conventional electronic parts of pretested quality. The parts are joined neatly, simply, and rigidly by a subsequent mass solder-dipping operation.

In addition to the cash award, the two engineers received the Meritorious Civilian Service award.

Paper Cable Saturants

G. E. BENNETT

IN EUROPE, the advantages of adding rosin to oil blends are considered to be (1) greatly improved resistance to oxidation under factory conditions; (2) increased electric strength; (3) increased cable stability and life; and (4) a viscosity–temperature characteristic consistent with the requirements of low viscosity at elevated temperatures, facilitating impregnation, as well as high viscosity at ambient and normal operating temperature, reducing drainage.

All these advantages are achieved while the dielectric loss angle (DLA) remains at less than 0.1% over the entire normal operating temperature range of cables from 10 C to 80 C, provided the rosin used is suitably selected and refined. Thus, the principal criticism leveled against the use of rosin 25 or 30 years ago has been answered.

Laboratory tests have shown that rosin compounds are more resistant to oxidation, as judged by change in DLA, than are straight oils and rosinless blends, in conditions of varying severity up to 8 days duration and 150 C with and without catalysts. Factory experience has proved predictions of a longer useful saturant life in the plant to be correct.

The electric strength of oils and compounds has been investigated, with a single stage impulse generator giving a ½ negative output wave, for temperatures ranging from ambient to 85 C. In experiments made to date using a 5-mil gap length, which is of the order of that to be found in the butt spaces of cable dielectrics, it has been found that an increase in electric strength at ambient temperature of approximately 30% may be expected from the addition of about 20% of refined rosin to a cable insulating oil.

The viscosity–temperature characteristics of oil–rosin compounds show a distinct advantage over those of oils. An oil blended with 25% rosin will have a viscosity at impregnating temperature perhaps 50% higher than the base oil, an increase which does not materially increase the time of impregnation, whereas at ambient temperature the viscosity may well be greater by a factor of 10 times. If a comparable percentage of polyisobutylene is blended with the base oil, the increase in viscosity at impregnating temperature is similar to that of the rosin compound but, at ambient temperature, is only double that of the base oil.

Wax bearing compounds have been developed having melting points, as determined by ASTM method *D 566-42*, in excess of 85 C, yet are sufficiently soft to permit satisfactory bending of the finished cable at subzero temperatures. Cables which are mass impregnated with compounds of this type are claimed to show improved electrical characteristics, as judged by poewr factor vs stress curves and electric strength, over the "drained" type cable. Troubles associated with compound migration in "solid" type cables are eliminated and, furthermore, the cables are cleaner to handle during installation, facilitating jointing operations.

Oils for hollow-core cables are produced by separating the primarily naphthenic components of the crude distillate from the aromatic constituents and refining the two oils separately. They are then blended in proportions which experience has shown to give most satisfactory results as assessed by cable performance. Lower viscosity in H.C.C. oil becomes an increasingly desirable characteristic as more economic cable designs are sought. The practical limit has been reached in a special oil developed in 1950 having a viscosity at 20 C of less than 14 centistokes compared with 35 centistokes of the "normal" grade of H.C.C. oil, while retaining excellent electrical properties. The viscosity–temperature characteristic at subzero temperatures shows the oil to even greater advantage, and at −20 C the viscosity of the special grade is five times less than that of the "normal" grade. The pour point of this oil is considerably below −50 F.

The effect of additives, particularly rosin, on the electric strength of H.C.C. oil has also been examined. Small percentages are found to increase the impulse strength to an unexpected degree.

In Europe, blends of highly refined oil and polyisobutylene are used in the manufacture of gas pressure cables of both the direct and indirect pressure designs. The saturants most nearly correspond to the compounds used in America for the impregnation of cables, but the preferred viscosity is between 400 and 500 centistokes at 60 C. The electrical requirements of such materials are of the highest order and a DLA at 100 C of 0.0005 is frequently specified.

Despite the vast amount of research which has been carried out in more recent years on plastics and rubber, materials increasingly used for low and medium voltage cable insulation, the oil-impregnated paper dielectric remains without rival, both from the technical and commercial aspects, for the insulation of high-voltage cables. In Europe, the addition of rosin is generally accepted as being beneficial for the impregnation of cables of the solid type up to medium voltages, and wax bearing compounds introduced about 5 years ago are likely to continue to gain in favor. Fundamental changes seem unlikely in oil blends for hollow core and gas pressure cable designs. High-voltage d-c cables are likely to introduce new compound problems, but principally a very flat viscosity–temperature characteristic would appear to be desirable.

Digest of paper 57-638 "Paper Cable Saturants, European Preferences and Selection," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

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Digital Computation of Transient Stability

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ASSOCIATE MEMBER AIEE

J. E. ROWE

A DIGITAL METHOD has been developed for solving the transient stability equations of an electric system in which induction motor performance is critical. All calculations are made using a stored program computer with 2,000 words of storage. Experience which includes 100 sets of step-by-step calculations for three electric systems indicates that the method is not excessively difficult to apply, and that costs are competitive with better known network analyzer methods.

The solution of the transient stability equations of a power system may be considered in three steps:

Collection of Data. The system data required is independent of the means used for solving the stability equations. Briefly, the data required are circuit configuration, per-unit impedances, load torque characteristics, inertia constants, voltage levels at important buses, and mw and mvar schedules of load and generation.

Preparation of Data. Initial conditions for the transient stability study are determined by the steady-state power flow that satisfies the mw and mvar schedules and desired voltage conditions. Motor slip speed, load torque, and the voltages behind transient reactance are calculated as part of the steady-state power flow. The electrical network is reduced to an equivalent circuit form containing (n) $(n\text{-}1)$ $(\frac{1}{2})$ elements in which n is the number of equivalent synchronous and induction machines represented for the study. Digital methods are available for both of these calculations.

Step-by-Step Calculations. Step-by-step solutions of the system of differential equations which apply are made for a period of 1 second. The digital procedure for the step-by-step calculations is summarized in Fig. 1, the digital flow sheet.

The cost of the digital data processing required for transient stability studies is as follows:

1. Preparation of data	
2½ hours computing	$95.00
2 hours card handling	20.00
	$115.00
2. Step-by-step calculations	
2 hours computing	$75.00
1 hour card handling	10.00
	$85.00

The engineering time required to produce a set of calculations is reduced toward a minimum because engineering is required only to specify changes from the prefault conditions. All decisions are made in advance of the actual calculations which are carried to completion with no operator decisions.

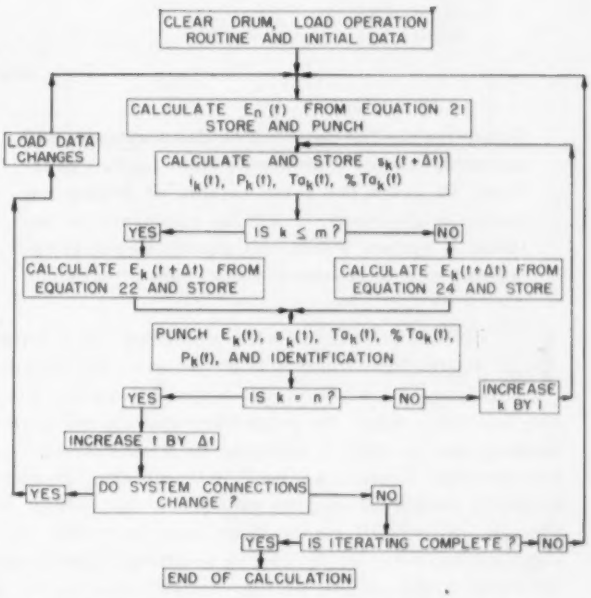
CLEAR DRUM, LOAD OPERATION ROUTINE AND INITIAL DATA
CALCULATE $E_n(t)$ FROM EQUATION 21 STORE AND PUNCH
LOAD DATA CHANGES
CALCULATE AND STORE $s_k(t+\Delta t)$ $i_k(t)$, $P_k(t)$, $Ta_k(t)$, $\%Ta_k(t)$
YES
IS $k \leq m$?
NO
CALCULATE $E_k(t+\Delta t)$ FROM EQUATION 22 AND STORE
CALCULATE $E_k(t+\Delta t)$ FROM EQUATION 24 AND STORE
PUNCH $E_k(t)$, $s_k(t)$, $Ta_k(t)$, $\%Ta_k(t)$, $P_k(t)$, AND IDENTIFICATION
YES
IS $k = n$?
NO
INCREASE k BY 1
INCREASE t BY Δt
YES
DO SYSTEM CONNECTIONS CHANGE ?
NO
YES
IS ITERATING COMPLETE ?
NO
END OF CALCULATION

Fig. 1. Digital flow diagram of transient stability calculations.

CONCLUSIONS

1. The methods and digital program have been highly satisfactory for making step-by-step transient stability calculations using a stored program type digital computer with a 2,000-word storage.

2. In making transient stability studies, such a digital computer has an economic advantage over network analyzers in the range of 4 to 1. In conserving manpower, the advantage is even greater, being in a range of 20 to 1.

3. Assuming that the maximum number of equivalent transfer admittances will be required to represent the network, a 19-machine system can be studied using a digital computer with a 2,000-word storage capacity.

4. The human element in data handling is reduced to a minimum, thereby reducing chances for mistakes. All data can be assembled and tested in advance and are fed into the computer under instructions from a data schedule.

5. Although this program was developed to study induction motor stability, it also can be applied to synchronous machine studies.

6. Very precise results can be obtained for the purpose of evaluating alternate methods of operation.

Digest of paper 57-683, "Digital Computation of Induction Motor Transient Stability," recommended by the AIEE Committees on Computing Devices and System Engineering and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

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Electric Distribution Developments for Future Residential Loads

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Future residential destribution developments will probably depart significantly from today's practices. To meet the requirements of higher kw customer demands, it will be necessary to develop a system which can absorb larger incremental load increases at a minimum of expense.

IN THE PAST 10 YEARS, engineers have found in electric distribution a fertile field for creative thinking and development work. Substantial progress has been made in promoting the use of higher primary and secondary voltages, in standardization of voltages and equipment, and in combining facilities formerly carried as separate entities in the system. Although the over-all results have been favorable, it is significant to note, in the case of overhead systems, that the basic scheme of assembling primaries, transformers, secondaries, and services is about the same today as it was 30 or more years ago.

With the impact of summer cooling loads on systems already extended by the increased loads caused by the building boom following World War II, it has become evident that the continuance of some former practices could "pile up" distribution investment and still leave the system inadequate for the future loads now being forecast.

In this author's opinion, future residential distribution developments will depart substantially from today's practices. To meet the requirements of higher kw customer demands, and to keep investment in line with revenues, it will be necessary to develop a system which can absorb larger incremental load increases with a minimum of system betterment expense.

PURPOSE

THE PURPOSE of this article is to present, in light of recent trends, a scheme for serving future residential loads. This scheme includes some ideas for changes in methods, equipment, and voltage classifications and is based on the following considerations:

1. Future installations of electric cooling and space heating equipment plus other high kw rated appliances will be prevalent in existing residential areas, as well as new areas.
2. An acceptable scheme must develop and make use of investment in existing facilities and be applicable on either a spot or group basis to both new and existing residential areas.
3. Distribution systems along residential streets will, for many years, continue to be overhead for reasons of economy and accessibility for servicing. However, future developments should anticipate the ultimate possibility of an underground system in some areas.
4. Single-phase 120/240 volts will continue to be the standard utilization voltage for the home.

On the premise that no one fixed set of conditions can be applied in all areas because of differences in existing facilities, policies, and practices, the scheme presented herein is intended to be flexible, and somewhat general, in scope.

It is the author's hope that this article will serve to stimulate further interest and study in new developments to solve the problems associated with future residential loads.

REVIEW OF RECENT TRENDS

TO ESTABLISH a systematic approach for the future, a brief review of recent trends will be made.

Fig. 1 will be recognized as a conventional 4-kv Y radial system, with express feeder, primary main, series street light circuit, lighting secondary, and power secondary, and serving, as an example, one of the earlier customers to have a central unit cooling system.

For illustration purposes, all circuits have been combined on the same pole as shown on the elevation of the pole structure, Fig. 1 (A). It is not uncommon, however, to see such structures on many streets today.

By the following sequence of system developments, the pole structure will be reduced to conform to present trends and practices:

1. *One Point of Delivery.* Increase the size of the lighting transformer and serve the customer's central cooling unit from the single-phase lighting service. Remove the open-delta power bank, power secondary, separate power service, and meter with the results as shown in Fig. 1 (B).
2. *Common Neutral.* Combine the neutrals of the 4-kv feeder and primary main, with the secondary neutral, as shown in Fig. 1 (C).
3. *Multiple Street Light Circuit.* Convert the series street light system to multiple, install individual luminaire control, and serve from the system secondaries. Remove the constant current transformer and series circuit, as shown in Fig. 1 (D).

Full text of a District paper presented at the AIEE Great Lakes District Meeting, Des Moines, Iowa, Apr. 15-17, 1957. Recommended for publication by the AIEE Committee on Transmission and Distribution.

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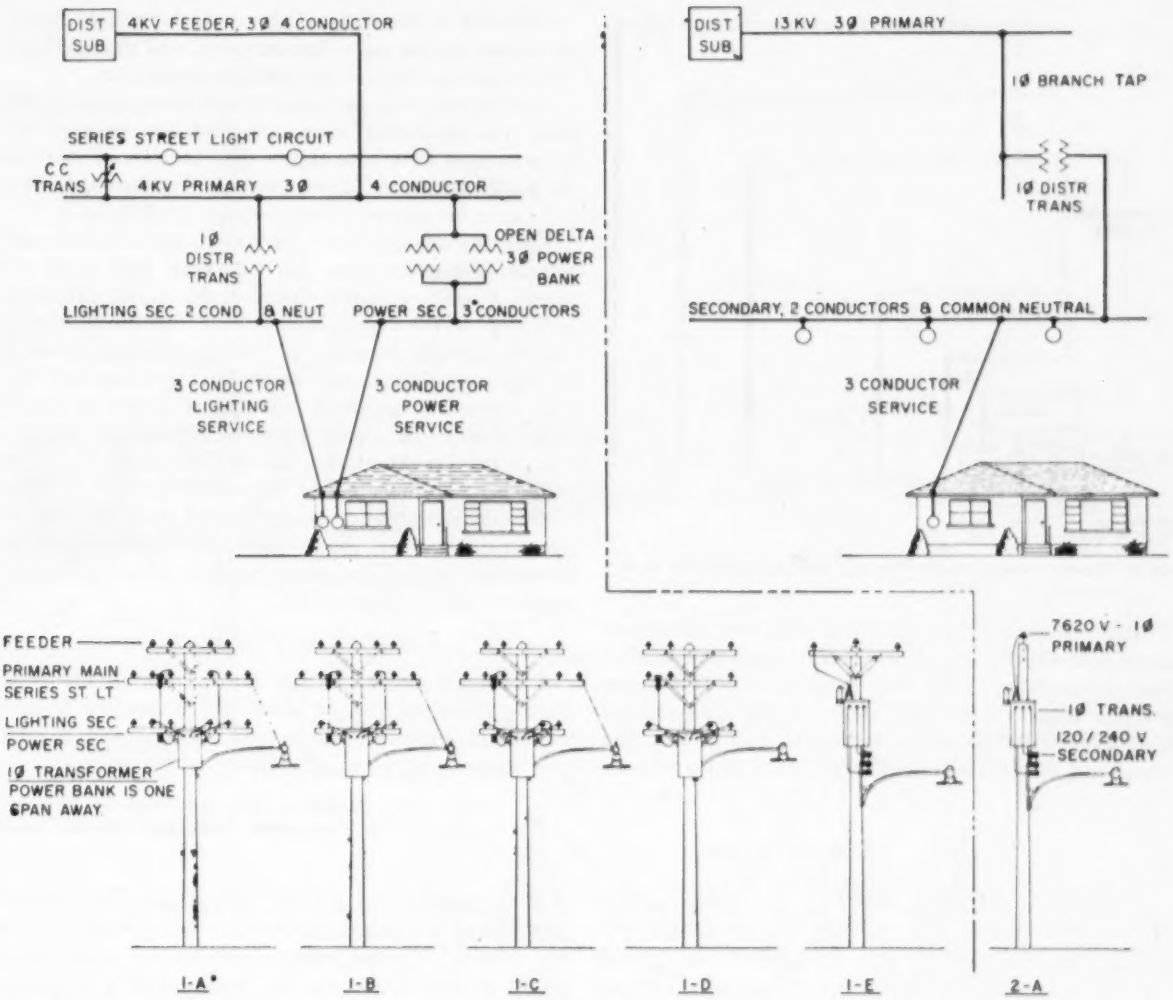


Fig. 1 (left). Conventional 4-kv Y radial system, showing sequence of developments of the pole structures. Fig. 2 (right). System, based on today's trends, having a single-phase 7,620-volt primary.

4. *13-Kv Primary.* Convert the 4-kv primary system to 7,620/13,200 Y. At 13 kv, the improved primary voltage regulation permits customer transformers and branch circuits to be tapped directly from the feeder, thus removing the need for the primary main. Removal of the primary main results in Fig. 1 (E).

5. *Single-Phase Residential Service.* Based on today's trend of single-phase service for residential loads and the fact that a single-phase 7,620-volt primary has as much capacity as a 3-phase 4-kv primary of equivalent conductor size, the final result is as shown in Fig. 2 and pole structure seen in Fig. 2 (A).

Therefore, for purposes of delivering today's single-phase load to residential customers, pole structure, Fig. 2 (A), carrying 4 conductors is equivalent in capacity to that in Fig. 1 (B) which carries 13 conductors.

In summarizing, it may be said that the foregoing developments and trends constitute a program of higher voltages and circuit capacity, of combining facilities formerly carried separately, and thus simplifying the system to reduce costs.

FUTURE LOADS AND PROBLEMS

THE NATIONAL AVERAGE residential kw-hr usage has been forecast (*Electrical World*, Sept. 17, 1956) at 8,000 kw-hr per year by 1970 or 2⅔ times greater than the present 3,000 kw-hr per year, and sales promotion campaigns aiming toward the all-electric home appear to be geared to make such forecasts a conservative reality.

It is reasonable to expect that a substantial part of the total kw-hr required to make up an average of 8,000 kw-hr a year will come with a much greater saturation of the higher kw rated appliances. Electric space heating, now being actively promoted in some areas to offset summer cooling peaks and improve system load factor, may be the principal usage item and the key to greater customer desire for other major electrical appliances, such as water heaters, clothes driers, and ranges.

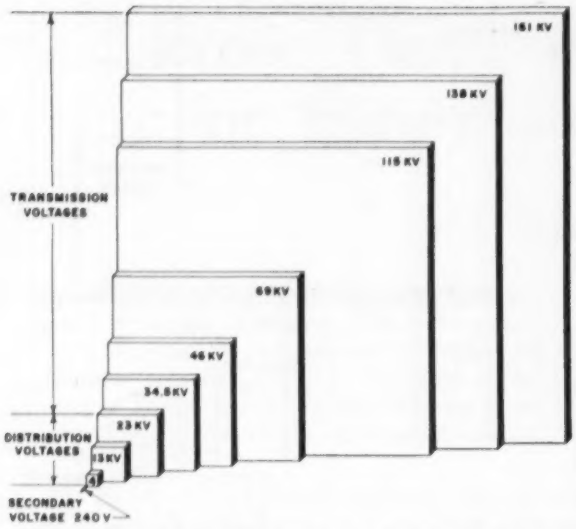


Fig. 3. Present voltage classification and relative capabilities in kv[2].

Data collected from experience with one all-electric home near Des Moines, Iowa, reveals consistent wintertime demands of 18 kw and indicates a 40,000 kw-hr per year usage. Of the total kw-hr, 30,000 are provided from a connected resistance heating load of 18 kw. The remaining 10,000 kw-hr will result from 26 kw of connected load in the form of the usual household appliances plus electric water heater, range, and clothes drier. This home has no comfort cooling equipment.

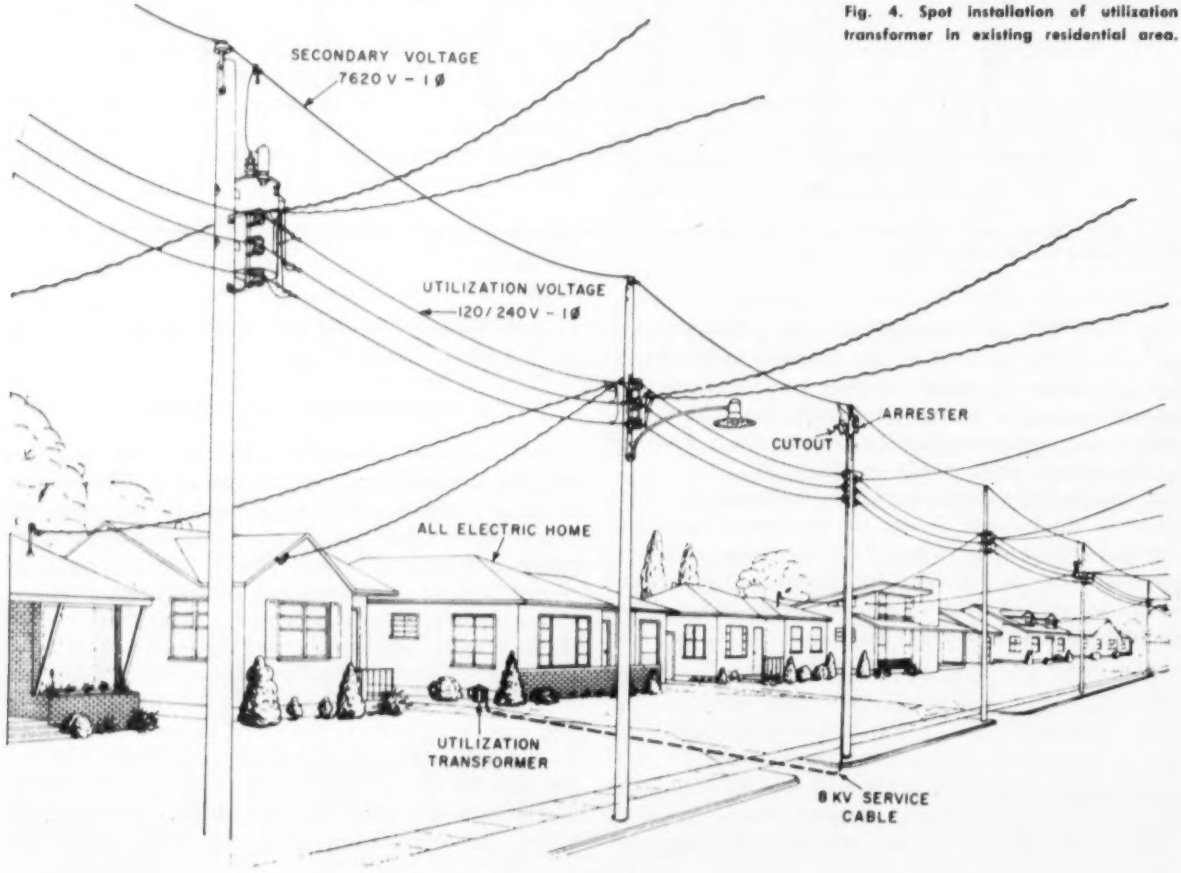
Such future loads in quantity will bring major problems. The residential group demand may be expected to increase at some rate higher than the rate of increase for kw-hr usage, and diversity at the residential service pole may, for any practical purpose, cease to exist.

With the thought that generation, transmission, and substation facilities can and will keep pace with the future diversified system demand, the major problems will come in the distribution system, and specifically at the distribution transformer and service pole. It is to be expected that future all-electric customers of the type previously described will appear at first in single units or in small groups scattered throughout the system in both existing areas and new developments. The problem, therefore, will be to provide initially for the higher kw demand of the individual customer and at the same time avoid the prospect of rebuilding existing transformer settings, secondaries, and services whenever another such demand occurs.

FUTURE DEVELOPMENTS

A POSSIBLE ANSWER to the distribution problems of serving future residential loads lies in developing new methods, equipment, and voltage classifications to provide wider application of existing system voltages.

Fig. 4. Spot installation of utilization transformer in existing residential area.



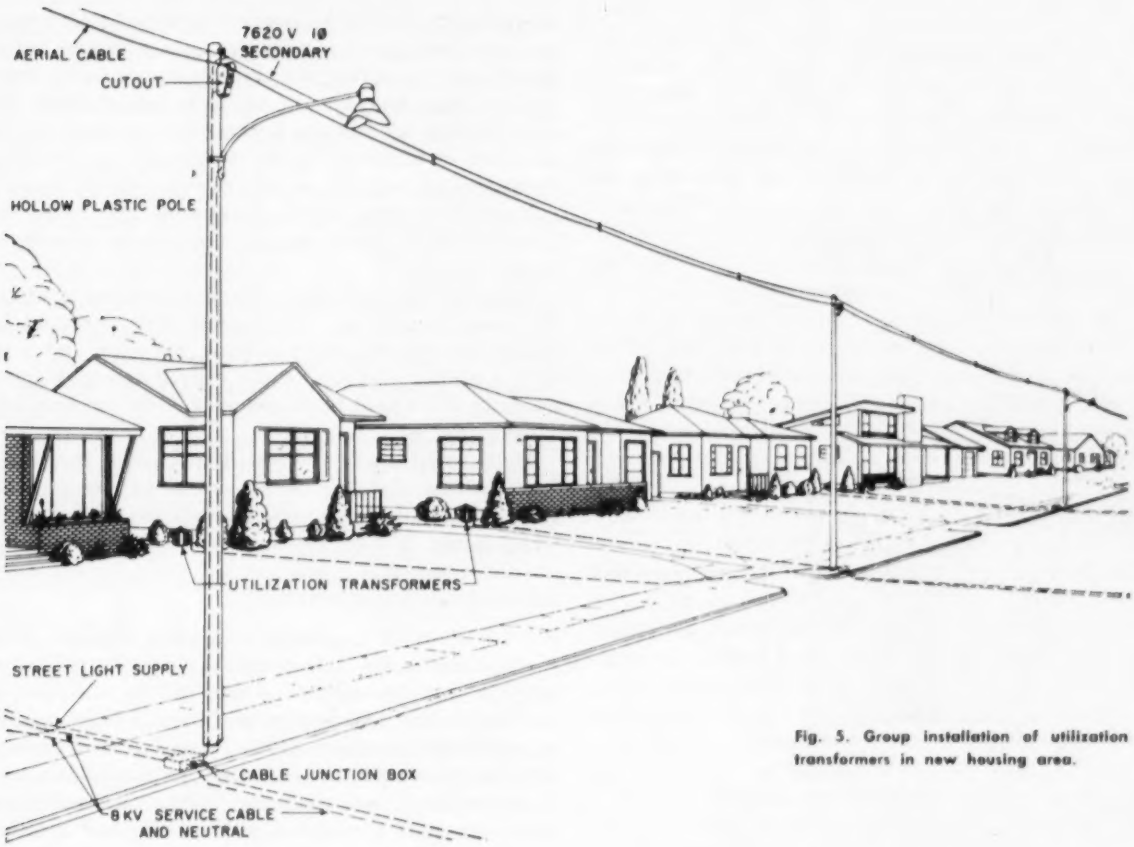


Fig. 5. Group installation of utilization transformers in new housing area.

For many years, system voltages in the range of 34.5 kv and 69 kv have occupied an important position as transmission or subtransmission voltages, capable of distributing bulk power to wide areas. On a much smaller scale, the same has been true of primary distribution voltages in the range of 4 kv and 13 kv, and secondary voltages below 600 volts. However, as higher customer demands increased the area load density, these same voltages became relatively less capable of area coverage, and higher voltages were superimposed on the system to deliver larger blocks of power. Fig. 3 is a simplified chart based on the assumption that load capability varies directly as the square of the voltage, and is designed to show the relative capabilities of some of the system voltages now in use. It is important to note that, although 4 kv and 240 volts have become relatively negligible quantities on the chart, their application in distribution systems has not changed.

In view of recent trends in electric distribution, and the thought that future customer loads will further reduce the relative performance of present system voltages, the following concept of future developments is presented:

69 Kv—A Primary Distribution Voltage. Voltages in the range of 34.5 kv to 69 kv will be relegated to the position of primary distribution voltages. System facilities at these voltages will be handled in much the same manner as they are presently, with the possible exception that a considerable number of single-phase and three-phase branch taps may be made between switching points, to serve small substations in suburban residential areas.

13 Kv—A Secondary Voltage. Voltages in the general range of 4 kv and 13 kv will be classified as secondary voltages, and utilized as such, including the installation of 7.6-kv or 2.4-kv services to residential customers.

In existing residential areas, the services to customers having the higher kw demands would be underground single-phase 7.6 kv or 2.4 kv with a utilization transformer installed as an integral part of the service. Existing pole-mounted transformers and secondaries serving other customers would not be disturbed until the saturation of utilization transformers became great enough to warrant their removal (Fig. 4).

In new housing developments, all customer services would be underground single-phase 7.6 kv or 2.4 kv, with each customer having a separate utilization transformer. Fig. 5 is a sketch showing an example of what could be done with such installations, using hollow plastic poles and separated aerial cable, with the neutral acting as a messenger and shield wire. The cable riser inside the pole terminates at the top in a bushing—cutout arrangement, the jaw end of the cutout being installed on the terminal which clamps the phase con-

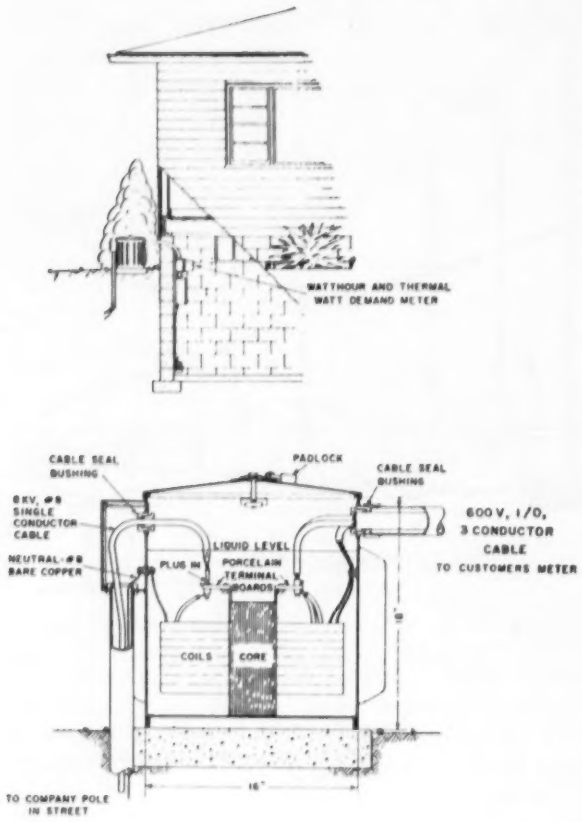


Fig. 6. Unit installation, showing cutaway view of utilization transformer, 5 to 15 kva, single phase, 7,620 to 120/240 volts.

ductor. Located at the base of the pole is a cable junction box in which the cable riser and services are terminated. The same junction box could also accommodate the secondary conductors, if a complete underground system were ultimately installed. Services to customers would be 8-kv no. 8 single-conductor cable accompanied by a bare neutral conductor of equivalent size. The system and service neutrals would, in all cases, be solidly grounded.

This same scheme could also be accomplished using the conventional wood poles and conductors shown in Fig. 4, with the choice of other equipment and the system voltage being a matter of local preference.

Utilization Transformer. The utilization transformer should be designed to accommodate a variety of kva ratings of core and coil assemblies in the same tank, with ready access provided to change the core and coils to suit the individual customer's needs. The customer's service and overhead system in the street would then become a highly permanent installation.

Fig. 6 presents an idea for such a transformer using a modified tank of a 15-kva single-phase 7,620 to 120/240-volt self-protected unit. The tank has been reduced in height and the bushings, arrester, tap changer, high-voltage protective link, and low-voltage breaker have been removed. Fin-type radiators were added to aid in heat transfer. The 8-kv and 600-volt service cables enter the tank through cable seal bushings located above the oil level, and all internal connections are made under oil. The entire unit may be semiburied or installed above ground with the service cables enclosed in rigid conduit to a point below the ground line. With the cover locked in place, this unit could be completely sealed.

Changing the kva rating of such a transformer would be a simple matter of removing the tank cover and internal connections, and replacing the core and coils with a similar assembly of the desired rating. Ratings up to 15 kva would be accommodated in the unit pictured in Fig. 6.

Many variations of the installation could be considered, the most desirable being a completely buried unit. However, a buried unit presents problems of heat transfer, moisture, and corrosion, which could preclude the use of conventional equipment and make further transformer development necessary.

120/240 Volts—A Customer Utilization Voltage. Voltages in the range below 600 volts, and specifically 120/240 volts for residential use, will be classified as customer utilization voltages and used in conformance with present customer practices. Present customer metering practices would not generally be disturbed although each customer having a separate utilization transformer would also have a combination watt-hour and thermal-watt demand meter, for the purpose of reporting transformer loading each time the meter was read. Ultimately, such meters might become a part of the utilization transformer.

Street lights in newly developed areas would be served individually by a small underground cable tapped off the nearest utilization transformer. In existing areas, the present practice would prevail until the saturation of utilization transformers became great enough to warrant a change.

ADVANTAGES AND DISADVANTAGES

ADMITTEDLY, the acceptance of this scheme would be decided by the local utility's consideration of such factors as cost, customer ownership of equipment, rates, and related revenues. However, a reasonable conclusion as to its desirability and practicality may be reached from the following listed advantages and disadvantages, as compared to present practices.

Advantages

1. Gradual development of existing system facilities and wider application of higher system voltages would inherently provide ample system capability for any foreseeable customer load, and would result in a highly permanent overhead distribution plant.
2. Flexibility of application is provided.
3. Simplification of the residential overhead system

would improve operating conditions, safety, and continuity. Tree trimming problems, and outages resulting from birds, squirrels, and lightning would be greatly reduced. Servicing and maintenance would require less pole work and heavy equipment, thereby reducing some of the problems encountered in rear lot line construction.

4. Improved appearance of the overhead system in the street plus the underground service would bring good reaction from the residential customer.

5. Close control of the transformer capacity installed, for actual load, would be possible with the utilization transformer described. Changing the transformer capacity to meet changing load conditions could be accomplished in a relatively short time as compared to present practices.

6. The present practice of the "educated guess" of load, diversity, and reserve capacity needed, would be eliminated.

7. Secondary-circuit losses and voltage drops would become relatively negligible quantities as compared to present methods of secondary distribution.

Disadvantages

1. The principal disadvantage of this scheme would appear to be the high initial cost of construction, based on the use of conventional equipment, particularly the utilization transformer. With such a unit for every home, the total capitalization in transformer capacity could be expected to be greater than if conventional practices were followed.

2. A transformer for every home would preclude the benefits of any diversity which did exist at the service pole.

3. Total system transformer losses would be greater because of more units and more kva installed.

CONCLUSION

FUTURE RESIDENTIAL LOADS will further aggravate the problems encountered with present distribution practices unless new developments are forthcoming. A new distribution scheme is desired which will provide more permanence and closer control of system investment, and at the same time be flexible in application, in order to develop and not outdate existing facilities. The scheme presented herein is intended to meet such requirements.

Further consideration of the economic aspects of this scheme is necessary. The apparent disadvantage of the initial high cost of one or more components may be more than offset by a substantial reduction in operating and maintenance costs. The cost factor should also be viewed in light of increased kw-hr consumption and revenues, and a comparison with present practices to accomplish the same purpose.

Diversity is an important factor to consider only if it can be used to advantage. Although future residential loads may provide some diversity at the service pole, experience may prove that it will not be dependable in the application of distribution transformers.

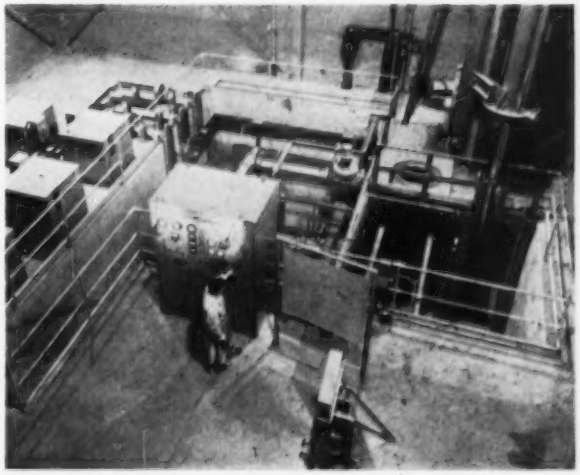
By comparison with present-day practices, the additional transformer losses provided by the utilization transformer scheme would be compensated for by the reduction in losses provided by the higher voltage secondary system and services.

Local governmental restrictions on the installation of high-voltage cable and equipment on the customer's premises might be a problem in some areas.

For the long-range outlook, it is the author's belief that this scheme has good possibilities for providing greater economy in electric distribution. What is needed today is a low-cost utilization transformer.

Vacuum Arc Melting Furnace for Alloys

At the Universal Cyclops Steel Corporation's Bridgeville, Pa., plant, this 16-inch capacity vacuum arc melting furnace is now in use for production melting of molybdenum and molybdenum alloys. Designed and built by the General Electric Company's Industrial Heating Department, the furnace casts an extremely pure ingot, since it removes gaseous impurities, reduces segregation, and produces a superior grain structure. At left, top, are 10 selenium rectifiers, producing a power supply of 15,400 amperes. At the operator's station are the "flow" type control panel, the viewing screen on which an image of the arc is projected, and the visual flowmeters for cooling water. The vertical cylinder to the right, rear, is the electrode housing in melting position. To load, the housing is swung over the electrode, and the electrode is drawn into the housing, then swung back over the crucible.



Development of Television in Canada

J. E. HAYES

TELEVISION BROADCASTING began in Canada in September 1952, when the first two television stations owned by the Canadian Broadcasting Corporation (CBC) went into service in Montreal, Que., and Toronto, Ont. These stations were built with a loan of $4.5 million which was provided by the Government of Canada for the purpose of establishing the nucleus of a Canadian television system. In the five years that have passed from then to the present, the television industry has grown at a rate which far exceeded all expectations, and already about 80% of the population of Canada has television service available. The number of transmitting stations has increased from the original 2 to 39, of which 8 are owned by the CBC, and 31 by private interests. In addition, eight more private stations are under construction and several other applications are pending.

The CBC operates two television network services, one in French and one in English, and all CBC and privately owned stations carry one or another of these services for part of their program schedules. The CBC has entered into contracts with the Bell Telephone Company of Canada, the Canadian National Railway Company, and the Canadian Pacific Railway Company for the provision of microwave service from coast to coast. About 2,000 miles of microwave networks are now in operation, and when the service is completed in 1958 to St. John's, Nfld., in the East, and Victoria, B.C., in the West, it will be well over 4,000 miles in length.

The original two CBC stations in Montreal and Toronto were equipped for making television film recordings, and as the number of CBC and privately owned stations increased, the recording facilities were expanded so that they were capable of supplying sufficient film recordings to feed these television stations until microwave network service would permit direct connection. At the present time, approximately half of these stations are on the network, and the other half are being fed by film recordings.

The English language network service now provides about 53 hours per week, of which 63% is Canadian production, and the remainder is imported, partly from the British Broadcasting Corporation but mostly from the United States.

The French network, which at present consists of two CBC stations and three privately owned stations, is fed about 57 hours per week, 69% of which is Canadian production. All CBC stations produce some programs for local service and so increase their total service to about 70 hours per week.

The present hours of service have been achieved by a continual growth in the studio facilities in Montreal and Toronto. In each city, the CBC began with two studios, one mobile unit, and one film chain. These have now been increased to five studios, plus one under construction, two mobile units, and five film chains.

The very considerable expansion in the amount of technical facilities has resulted in some very definite changes in system design, which are being carried into the planning for the more recent studios. Initially, the film reproducing equipment and its control and monitoring facilities were contained in the master control room. Although this arrangement worked satisfactorily for a short time, the activity in master control soon became so great that good operation was very difficult. It was decided to separate some of the functions from master control and to handle them in separate locations.

In the arrangement now in use, the basic idea followed is the divorce of all program production functions from master control, making it solely a distribution and quality control center. To this end, a transmitter booth has been set up for each local station; a utility booth is used for production of film shows, remotes with local cut-ins, and network shows with local cut-ins which are intended for transmission onward to the network. Separate film reproducing rooms are used for originating film, and the film recording room remotely controls the selection of programs which are to be recorded.

The newest CBC studios are equipped with considerably more versatile vision mixers than were provided in the first studios. Complex programs now being produced require a mixer with eight input and four or five output circuits. Inputs frequently required are three cameras, one film chain, one remote studio or mobile unit, one network, and one special effects feed. Outputs used are the main output, an effects output, a fade or dissolve output, and one or two preview outputs.

The complexities of the aforementioned systems necessitate very close control of the performance characteristics of the individual pieces of equipment involved, and in order to achieve this a considerable amount of test equipment is being provided and comprehensive maintenance and testing routines are being established.

Discussion so far has centered around the growth of the transmitting end of the television system. The picture would not be complete without some reference to the public's acceptance of television. The sale of television receivers has been even more rapid than the industry had anticipated. Already over 65% of Canadian families have television sets, and in areas where the service has been available for some time, the proportion is as high as 80%.

Digest of Paper 57-665, "The Development of Television in Canada," recommended by the AIEE Committee on Television and Aural Broadcasting Systems and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Communication and Electronics*, 1957.

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138-Kv Pipe Cable Construction

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IN 1956, Public Service Electric & Gas Co. constructed a 13-mile, 138-kv pipe cable from West Orange (N.J.) switching station to a proposed switching station in Cranford. Special construction was required to permit this cable to be rated up from its normal value of 190 mva to 225 mva, to meet high terminal pressures resulting from a static head of 515 feet, and to anchor the cable on a steep grade near one end of the line.

For usual conditions, the rating of a 2,000-MCM cable in 8 inch pipe is 190 mva. The rating may be increased by raising copper temperature, increasing pipe size, increasing pipe depth, triangulating the cable, and lowering the thermal resistance of the installation. The first three of these means were rejected as either unsafe or uneconomical. Triangulation appeared to be only a mechanical problem. The applicability of resistance correction was determined on the basis of (1) tests on an experimental installation using various backfill materials and (2) a soil resistivity survey along the route of the proposed line.

Wide variation in resistance values and poor correlation between resistivity and density measurements were encountered, so that general resistivity correction appeared necessary. The investigation culminated in the development of a blend of two commercial sands containing a total of about 8% of fire clay. It has a resistivity of about 40 watt-cm units. The clay improves moisture retention of the sand and prevents segregation in handling.

The plan for increasing the line rating from 190 mva to 225 mva was intended to be accomplished in two steps. The first step was to raise the rating from 190 mva to 215 mva by corrective backfill, and then from 215 mva to 225 mva by triangulating the cable. For the first of these steps an over-all earth resistivity of 66 watt-cm units was required. On 78% of the total line length, this was achieved with corrective backfill in a trench 24 inches wide; over the remainder, corrective backfill in a trench 36 inches wide was required to reduce the resistivity to 66 watt-cm units.

The cable was triangulated as part of the pulling operation, by tying it at 20-foot intervals with a nylon tape. The normal pulling speed of 30 feet per minute was maintained without difficulty The setup is in Fig. 1. By observation through windows cut into the pipe, it was found that pulling through bends in the pipe does not disturb the ties on the cable.

To eliminate the effects of hot spots occurring in poor soil areas, the pipe oil is oscillated over a distance of 500 feet at intervals of approximately two hours. This is accomplished automatically from the low end of the line by means of float switches that selectively operate pump controls so that oil moves alternately in two directions.

Fig. 1. Triangulating cable with ties during pulling.

At the upper terminal, the line is level for 950 feet, then falls through 230 feet in the next 3,000 feet. The possibility of the cable ratcheting downhill is attended by the need for protecting the cable insulation against the effects of tension created by this action. This is done by introducing an S-bend into the pipe to reduce sidewall pressures both in the pipe and at the termination assembly, to values below 100 pounds per foot.

CONCLUSIONS

1. The thermal resistance of pipe cable installations may be corrected economically by using graded quartz sand as backfill.

2. It may be more economical, in particular cases, to use corrective backfill as standard practice than to make extensive resistivity surveys.

3. Triangulating the conductors by tying them together during pulling is a practical and economical means of reducing pipe losses.

4. With large size pipe cable, it is more economical to increase ratings by triangulating the cable and using corrective backfill than by increasing conductor size or pipe size.

5. Oscillation of pipe oil may be of advantage in lowering the temperature of potential hot spots in pipe cable.

6. Cable on steep grades may be anchored there by the deliberate introduction of pipe bends into the installation.

Digest of paper 57-652, "Thermal and Mechanical Problems on 138-Kv Pipe Cable in New Jersey," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

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Radiation Hazard Control in a Power Reactor Installation

R. M. TAYLOR

Operational control problems to insure adequate protection from the two main types of radiation damage—somatic and genetic—fall into two general categories: control of external radiation and control of radioactive contamination. The author in his discussion draws on the experience gained at the Chalk River nuclear plant in Canada.

THE GENERAL CHARACTERISTICS of radiation have been known for over 50 years. Painful experiences have taught many of its dangers as well. Within a year of Roentgen's discovery of the X ray, which was reported in 1895, descriptions of X-ray burns of the eye and of the skin were published. By 1902, there was good evidence that X rays could cause cancer.

But, prior to 1942, sources of radiation were for the most part confined to X-ray tubes or relatively small amounts of radium in sealed containers. Although some of the problems consequent to the use of radiation were becoming apparent, they were not a source of public or general medical concern.

Since 1942, developments in nuclear physics have fostered an atomic industry employing tens of thousands of workers who must handle great quantities of radioactive substances. During the same period, the need for supremacy in atomic weapons has resulted in a release of vast quantities of radioactive materials that have been broadcast over the face of the earth. The possible effects of this world-wide contamination have heightened public interest in the dangers of radiation.

Ionizing radiation is simply another form of energy related to heat, light, radiowaves, etc. It is a source of potential damage to any biological system including man. The harmful effects depend in part on the type of radiation, the portion and site of the body exposed, the age of the person, and the size and rate of delivery of the dose.

Once the energy has been absorbed, there is a complex series of physical and chemical changes that has as its final expression the visible changes that are described as the effects of radiation. There has been much study of this problem but, as yet, there is no way to reverse the effect or to prevent it. The answer is prevention of exposure so that important amounts of radiation do not reach the system.

Essentially full text of a conference paper presented at the AIEE Summer General Meeting, June 24-28, 1957. Recommended for publication by the AIEE Committee on Safety.

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TYPES OF RADIATION

THE TYPES OF RADIATION that are of interest are alpha and beta particles, neutrons, and gamma and X rays. They are grouped under the term "ionizing radiation" because they have directly, or indirectly, the property of producing electrically charged particles or ions in their path.

These forms of radiation vary greatly in their ability to penetrate the body. Alpha particles and beta particles give up all of their energy and are stopped in the skin and superficial tissues if their origin is outside of the body. X rays, gamma rays, and neutrons pass through the body and deliver only a portion of their energy to the tissues. They deliver, therefore, a fairly uniform dose to all tissues. Although radiation from beta particles can cause severe burns of skin, the most serious hazards from external sources of radiation are caused by gamma rays and neutrons. Because neutrons are found only in the neighborhood of reactors that are operating and because reactors have been carefully designed to control such exposures, in practice the gamma rays constitute the major hazard.

If sources of radioactivity are absorbed by the body, the order of importance is reversed. Either the lung or the intestine may receive heavy radiation by alpha and beta particles because of the complete absorption of their energy in a small sphere above their site. Some alpha and beta emitters are selectively deposited in bone or other tissues and if present in sufficient quantity will damage those tissues. Of less importance are the gamma emitters with less concentrated radiation. Among the radioactive materials that concentrate in specific parts of the body are radioactive iodine, which is deposited in the thyroid, plutonium and strontium-90, and radium which is deposited in bone.

RADIATION DAMAGE

THERE ARE TWO MAIN TYPES of radiation damage that may be encountered.

The first is direct damage to the individual or somatic damage. The somatic effects may be divided into early and late effects.

The most dramatic of the early effects is acute radiation sickness as encountered among the survivors of Hiroshima and Nagasaki, and as experienced by the Japanese fishermen and Marshal Islanders who were affected by fall-out from test explosions in the Pacific.

Unfortunately, there has been also some experience with this effect in atomic energy projects as the result of accidents. It is probable that a dose of 150 roentgens delivered to the entire body will produce acute radiation sickness in a proportion of those exposed and that a dose of 500 roentgens will be ultimately fatal to 50% of those exposed. The hallmarks of acute radiation sickness are nausea, vomiting, followed by diarrhea and accompanied by a dramatic fall in the number of circulating red and white blood cells. (NOTE: one roentgen may be considered as a unit of radiation roughly equivalent to the quantity received in one hour from a one-gram source of radium at a distance of one yard.)

Other early effects of a more localized nature include acute radiation burns, which are indistinguishable from burns resulting from absorption of other types of energy. They are treated as are burns of any type. The only difference between them and other burns is that they tend to heal much more slowly. Among workers in atomic energy projects, acute radiation burns of the skin have followed exposure of the skin to serious contamination by radioactive materials emitting beta particles. The burns have occurred on the hands and could have been avoided had the workmen taken the precaution to wear thick gloves.

The late effects of radiation include atrophy of the skin as encountered in members of the medical profession who have been working with radiation for many years, cancer of the skin or of the bone or other tissues as a result of severe radiation injury, and leukemia or cancer of the white blood cells.

Cancer of the bone has been encountered most frequently in those who accidentally absorbed radioactive materials such as radium, which were deposited in bone. This has not occurred as a result of any accidents in atomic energy plants but has been a serious problem in industries such as the luminizing industry.

The incidence of leukemia is eight times higher in radiologists and one hundred times higher in the survivors of Hiroshima than in the general population. A more recently established effect has been a shortening of the life-span of those who have been exposed to significant amounts of radiation. A study of the average life-span of radiologists suggests that there has been a reduction of up to five years in their life expectancy.

To avoid these effects, of which the most easily induced is leukemia, it is suggested that the lifetime dose to any individual should be less than 200 roentgens and that this should be received over a long period of time at a rate not in excess of 0.3 roentgen per week. The same rule would apply to the radiation from radioactive materials absorbed by the body; in other words, the maximum permissible amount in the body should not exceed that which would deliver a dose to the organ in which it is deposited of more than 0.3 roentgen per week.

The second main type of damage that may be encountered is genetic damage. That is to say, damage that would be transmitted to future generations. Since most children are born to parents under the age of 30, the most important period for the individual is from the age of conception to the age of 30. The genetic damage is damage inflicted on the germ cells and, in particular, on components of the germ cells that are responsible for the transmission of hereditary characteristics. Since 2 to 3% of the population is carrying serious hereditary defects any increase should be avoided if possible. It has been estimated that a doubling of genetics defects would be produced by exposure of the population to a dose of 50 roentgens per 30-year generation for many generations. To reduce genetic damage, it is recommended that the individual exposed to radiation should not receive more than 50 roentgens by the age of 30 and not more than an additional 50 roentgens by the age of 40. Population dose should not exceed from 3 to 10 roentgens per generation.

OPERATIONAL HAZARDS

IN THE OPERATION of a nuclear reactor, the fission of uranium leads to the accumulation of fission fragments which, in a relatively small reactor, represents an amount of radioactive material roughly equivalent to 300 or 400 tons of radium. Reactors built to produce industrial power may be of several types. The only type with which any considerable experience has been gained is the one in which solid fuel elements are used.

In the operation of such a reactor, the fuel elements must be removed from time to time, and must be processed to separate plutonium and uranium for reuse from fission products. The fission products may be subjected to additional treatment to separate other useful by-products before being stored.

The problems that arise in such an operation may be discussed under the general headings of Control of External Radiation and Control of Radioactive Contamination. In each case, one must remember that the permissible amount of radiation is very small. The worker should not be exposed to external radiation in excess of 0.3 roentgen per week. He should not be allowed to absorb into his body amounts of radioactive substances that will deliver doses to any organ of more than 0.3 roentgen per week. To relate this permissible dose to other known types of exposure, it may be useful to point out that an X ray of the spine will deliver between 6 and 9 roentgens to that part of the body, that a complete X-ray examination of the stomach may result in a dose to that area of the body of up to 40 roentgens, and that the operation of a fluoroscope may deliver between 2 and 40 roentgens per minute to the part of the body being examined.

CONTROL OF EXTERNAL RADIATION

AS DR. H. M. PARKER[1] has pointed out, there are no unsolved problems in this category. Control is exercised by shielding, distance, and time. Except in the case of unexpected circumstances, the design of reactor installations provides for sufficient shielding. Where shielding is neither desirable nor practicable distance can be used, and finally, limitation of time of exposure can be used when neither of the first two methods of control

can be employed. To measure exposure to external radiation widespread use is made of film badges, which are worn by the workers. The films are blackened by ionizing radiation in proportion to the dose. By developing the films under standard conditions a reasonably accurate estimate of the dose received by the worker can be obtained and used to control future exposures.

CONTROL OF RADIOACTIVE CONTAMINATION

In this category are included all problems consequent to the escape of radioactive materials into the air, onto the working surfaces, or into the environment of the installation. To date, it has not been possible to eliminate contamination by design. Any design is only as good as the operator, and human error has confounded the most carefully thought out safety features. The contamination may cause two main types of problems.

First, the radiation may be such that it constitutes an external hazard. As in the case of other external hazards, the use of temporary shielding, distance, and time, will prevent overexposure of the worker.

Second, the radioactive material may ultimately find its way into the body because it is inhaled or swallowed or because it is absorbed through the skin. Inasmuch as there is no way of accelerating the elimination of radioactive materials from the body, the only control is prevention. Control is, therefore, exercised in three main ways:

Control of the Contaminated Areas: by means of barriers to control traffic; by the use of protective coating equipment; by surveys of clothing and skin at the entrances and exits; by decontamination of the working surfaces, of clothing, etc., and by control of movement of equipment. In connection with the latter, it is generally accepted that once equipment has been moved into a potentially contaminated area, it should never be removed for any reason..

Control of ventilation: There is no cheap way of exercising this control. Whenever short-cuts have been taken in an attempt to reduce the cost of installation of ventilation, there have been problems that have made the final cost very high.

Control of Personnel: by monotoring the skin and clothing of the worker, by decontamination of the skin, by prompt treatment of contaminated wounds, by radiochemical analysis of urine for evidence of a body-content of activity, and by external monitoring of the worker to measure total body radioactivity.

It will be seen that there are no new principles enunciated in the control of the hazard of radiation that have not already been used in the control of other hazards. Perhaps the only difference is in the degree of control required. For some toxic materials, it may be necessary to maintain air content at a few parts per million. In the case of radioactive iodine, the permissible amount in the air is one part in 50 quadrillion.

In spite of all precautions, major accidents may occur that will overwhelm all normal control measures. For such instances, it is important that a disaster plan be prepared. It must be prepared well in advance and must be based on the assumption that the worst possible accident will occur.

CHALK RIVER EXPERIENCES

IN THE FIRST PLACE, it has been learned that is is important that the staff be fully informed of the nature of the hazards and the steps being taken to control them. In the Chalk River Project, to date, there have been no problems with labor unions insofar as health hazards are concerned because of the time spent in explaining these matters to their members. The most commonly expressed fear of the average worker is that radiation will cause sterility. Added to this is a certain amount of fear of the unknown inasmuch as radiation is not detected by the body senses.

In the second place, it is of the greatest importance that there be complete co-operation between the medical services, the operating staff, and the radiation hazard control staff. Each has a part to play in controlling the hazard and their efforts must be co-ordinated and must be based on mutual confidence.

In order of frequency, the following problems are encountered:

Contamination of Body Surface: In an installation such as the Chalk River Project, it is inevitable that amounts of radioactive material in solution are being carried from place to place in the plant and are being taken from room to room within the laboratories. It is also inevitable that some of these will be spilled, that there will be breaks in technique or flaws in the equipment that will result in contamination of the skin. Because all laboratories are equipped with change rooms and washing facilities, in most cases the contamination can be successfully handled by showering or scrubbing. In those instances where the contamination is of a greater degree, the worker is referred to the plant hospital, where more extensive decontamination procedures can be carried out. Latterly, this has involved the use of complexing agents such as versene to combine with the contaminant chemically or to neutralize it, which has been of considerable use in reducing the contamination. Inasmuch as the active material may be in an acid solution, it is often found that the contamination is fixed to the skin. In that case, it has not been our experience that significant amounts have been absorbed through the skin. Over a period of a few days, the contamination is reduced as the skin is renewed in the normal fashion.

Overexposure to Radiation: By overexposure is meant exposure in excess of 0.3 roentgen per week. The greatest importance is placed on the necessity for maintaining the maximum dose received by the worker at an average level of less than 0.3 roentgen per week. There are certain areas in the plant, such as the areas where chemical extraction of the fuel elements is carried out, where it is most difficult to maintain this level. In those cases, advantage has to be taken of the reduction in permissible working time of the worker so that the average exposure is kept within safe limits.

Internal Contamination: By this, reference is made to the absorption of active materials by the body. Of these materials, the one about which most concern is felt is strontium-90. This substance is well known because it has been the subject of considerable debate in discussions of the hazard from fall-out. Strontium-90 is a beta emitter that behaves like calcium in the body and is deposited in bone. In experimental animals, it has been demonstrated that bone tumors can be produced by this material. Inasmuch as the materials most feared are those alpha and beta emitters whose energy is completely absorbed very close to their site, it will be apparent that there is no useful way of measuring the contamination by instruments outside the body. It has been found that a proportion of these substances is excreted in the urine. An estimate of the body content can be reached by examining specimens of urine for their content of active materials.

There have been two major accidents at Chalk River. The first one occurred before there was an adequate disaster plan. It was a chemical explosion and resulted in the death of one worker as a result of the explosion, and injuries to three others. These were admitted to the plant hospital. Their skin was covered with a mixture of cement dust, wood splinters and mixed radioactive fission products and they had multiple cuts and contusions. Because there was inadequate control of the traffic in the hospital, it was ultimately necessary to remove approximately four truckloads of contaminated material, and it was some days before residual contamination could be removed. The decontamination of each of the injured workers took from three to nine hours, much of it under general anesthesia. As had been found in other cases, it was not practicable to decontaminate the hair and this had to be shaved. No permanent damage resulted from this exposure and all of the workers are alive and well.

By the time the second major accident occurred, there was a disaster plan that was effective in controlling traffic and reducing the confusion. This accident followed a power surge in the reactor that led to the release of a very large quantity of mixed fission products in water in the basement of the reactor building. This constituted a serious external hazard to the workers who had to go into the contaminated area in order to carry out reconstruction. It was obvious that shielding and distance could not be employed and control was exercised therefor by limiting the amount of working time of the individual in the danger area. In addition, key personnel were kept out of the contaminated areas and extensive use was made of those who were not normally exposed to radiation in their jobs. Although it was not possible to keep exposure within the limit of 0.3 roentgen per week, it was possible to keep it well within the permissible amount for a year, i.e., 15.6 roentgens. As a matter of fact, with one exception, no worker received over 10 roentgens during the period of reconstruction, which lasted for 14 months.

A second hazard was the danger of absorption of active materials by the body. Very early, it was learned that the respirators were not as efficient as had been hoped and that because of poor respirator discipline the workers were inhaling amounts of active material that might be of importance. This situation was brought to light by examination of the urine and led to a major concentration on a proper maintenance program for respirators, proper fitting of the respirators, and instruction in respirator discipline. By constant check of the workers exposed those who were found to be excreting significant amounts of radioactive materials were removed from the active area until further tests demonstrated that their body content was not of importance. During the period of reconstruction, approximately 300 workers were removed for this reason for periods of from a few days to a whole year. It was possible to give them work in other nonactive areas of the plant so that no worker lost money because of this exclusion. This, of course, was an important factor in preventing labor–management problems.

It is hoped this article has proved that, under present circumstances, first aid should never be required insofar as acute radiation effects are concerned in a nuclear power plant.

There is one last question which has not yet been answered. How safe should one make such an installation? In no other type of industry has the same effort been made to make the operation 100% safe. A certain amount of hazard is accepted in such industries as, for example, the building industry, and it may be that an undue amount of effort has been spent to insure that no one is injured by radiation. In the light of present discussions and public concern about radiation, however, it is unlikely that there will be any change in this policy in the near future.

REFERENCES

1. Health Problems Associated with the Radiochemical Processing Industry, H. M. Parker. Archives Industrial Health, Vol. 13, p. 454, 1956.

Satellite "Weather-Eyes"

Two intricate optical devices, each hardly larger than a pack of cigarettes and weighing less than 4 ounces apiece, will measure the radiation reflected by the earth's cloud layer as the earth satellite spins in its orbit after launching during the International Geophysical Year.

If successful, the new "weather-eyes" will help meteorologists gather information on cloud makeup and patterns for study and weather prognostication. Presently, long-range weather forecasts are based on information covering only about 5% of the earth's surface. The patterns, thickness, types, and moisture content of clouds are key clues to forthcoming weather.

The devices were developed by the Perkin-Elmer Corporation for an experiment which has been planned by the U. S. Army Engineering Laboratories at Fort Monmouth, N. J.

Early Electrical Machines

BERN DIBNER
FELLOW AIEE

This is the sixth and concluding article of a series on pioneering investigations in electrical science. The development of electrical instruments and the contributions of Alessandro Volta, whose voltaic pile initiated a new era in electrical science, are recounted.

THE EARLIEST DETECTOR of the electric charge was the "versorium" of Gilbert, a rough, qualitative, pivoted electroscope described in his book in 1600. More than a century passed before use was made of a pair of silk threads which, by the degree of their divergence, roughly indicated the strength of a charge. John Canton improved this indicator by adding small pith balls to the ends of a pair of linen threads. Tiberius Cavallo in London in 1770 made an indicating electroscope of silver wires with pith balls at their ends, and these were enclosed in a glass jar with tinfoil strips fixed down the sides.

In 1787, Abraham Bennet invented the goldleaf electroscope, a sensitive indicator still in use today. He arranged a glass bell jar capped by a brass disc from which a short brass rod or tube projected down into the jar. Two strips of goldleaf were attached to this rod and additional strips of tinfoil were pasted on the inside of the jar facing the goldleaf strips. The jar eliminated the influence of moving air. The divergence of the strips in Bennet's electrometer was measured on a graduated paper scale. The instrument was sufficiently sensitive to register the evaporation of water from a metal vessel placed on the cap of the instrument.

Quantitative measurement came with William Henley who, in 1772, hung a pith ball on a thin piece of cane pivoted at the top of a quadrant (Fig. 1). A charge brought near the ball caused the arm to move angularly outward, indicating the degree of motion on a graduated ivory semicircular scale fixed to the quadrant. With this electrometer Henley compared the conducting powers of different metals by the charges required to melt one inch of wire of each metal.

A considerable improvement in a combined indicating and recording electric instrument was the novel "ceraunograph" invented by Giovanni B. Beccaria (1716-1781), a leading physicist at the University of Turin. His voluminous books and many letters, beginning with his earliest in 1753, were as widely read as those of Nollet and were translated into English, French, and Latin. He supported Franklin's theory of the action of the Leyden jar and repeated Franklin's kite experiment. In Beccaria's instrument two iron wires were pointed, one was attached to the lower end of a tall insulated vertical conductor, the other was led to ground. The pointed ends formed a spark gap and through this gap a cardboard strip was made to move at a uniform rate by means of clockwork. Passing storm clouds caused sparks to pass between the points and so holes were punctured in the cardboard; the size and frequency of these holes provided a graphic record of the electrical atmosphere overhead.

An electrometer devised by Horace B. de Saussure (1740-1799) improved that of Cavallo, by using very fine metal wires terminating in pith balls. However, he added to this an ingenious attachment to measure the degree of electrification of the atmosphere some 50 feet above him. To the top of the electroscope he loosely set a metal cap to which was attached a long, flexible, braided silver wire terminating in a lead ball weighing three or four ounces. As De Saussure threw the ball vertically upward, it collected charges which activated the electroscope until the wire's full length was reached. The cap was then detached from the instrument leaving the final register upon it. Different atmospheric conditions could thus be determined and compared by the electrometer indications. It was probably to De Saussure that Franklin, in 1772, wrote a short summary of the positive effects of his lightning rod. An early supporter of Franklin's lightning rod proposal, De Saussure erected such a rod in Geneva in 1771.

ALESSANDRO VOLTA

ALESSANDRO VOLTA (1745-1827) was the initiator of a new era in the evolution of electrical science with the invention of the voltaic pile or direct-current electric battery, made public in 1800. However, for some 30 years prior to that, as professor of physics at the universities at his native Como and at Pavia, he experimented and wrote on electricity. His first publication was published in 1769. In the field of electrostatics, he became famous for the discovery of the "perpetual electrophorus" which he announced in 1782. The electrophorus (meaning that which carries off electricity) was the earliest machine operating on the principle of electrostatic induction or "influence," as it was later called, as it operated on electric charges produced at a distance. The device itself consisted of a thin plate of insulating material resting on a metal sheet called the "sole plate" (Fig. 2). On the insulating plate rested another metallic disc to which a handle of glass or other insulation was attached so that the upper disc could be lifted from the insulating plate. Thus, a loose sandwich was formed

Partial text of "Early Electrical Machines," published by the Burndy Library.

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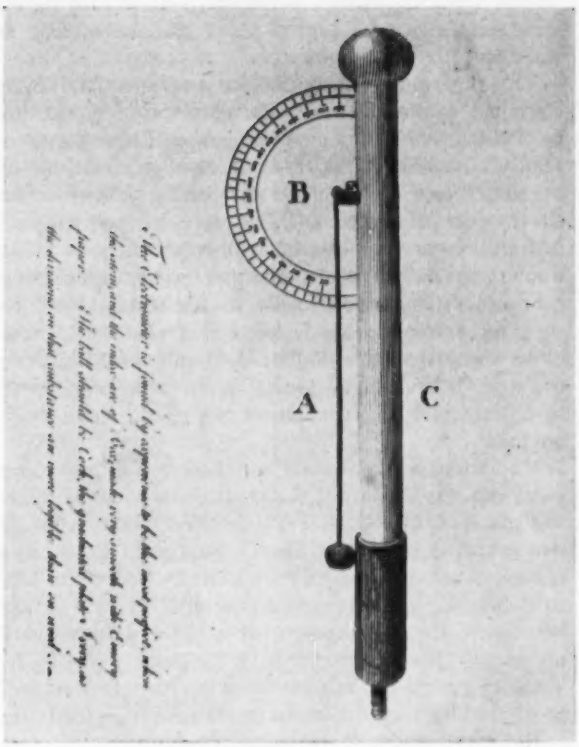

Fig. 1. Henley's electrometer.

of two metal discs with a resinous insulating plate between. To use the apparatus, the top disc was lifted and the resinous plate was lightly whipped with a strip of cat's fur or fox tail. The upper disc was then replaced on the excited surface of the resinous plate. A finger was brought to the upper disc thereby drawing off the free charge; the disc was then lifted by the handle and it remained charged with a charge opposite to that of the resinous plate. A finger approaching it drew a spark.

If the metal was returned to the resinous plate, the process could be repeated many times (therefore "perpetual"). The dissipation of electricity from the plate's surface resulted in the gradual diminution of the electric charge. None of the original charge was removed by the upper disc because it was an induced charge by the lower plates that provided the spark. Lifting the upper disc required that work be done, for the piece was held attracted to the insulator. Although the idea of induced charges had been known for many years, no earlier apparatus had been constructed on this principle or was so easily capable of demonstration. In addition, this provided the idea for the construction of other apparatus using the same principle. "Doublers" and "multipliers," in stationary and rotating form, were built. Their greatest complexity and popularity was in the mid-1800's when the machines of Varley, Holtz, and Wimshurst came into wide use in medical treatment.

A modification of the electrophorus was Volta's "condensing" electroscope in 1782, in which a thin layer of resin replaced the cake, and the sole plate had a pair of hanging metal leaves suspended from it into a globular glass jar. With such a sensitive instrument, Volta, Laplace, and Lavoisier found that, in the burning of coals, in the reaction of iron filings in vitriol, and in the evaporation of water, accompanying charges of electricity were created. Volta also tried to introduce electrometric standards by using what had been earlier proposed in London and on the Continent: to determine the attractive pull of a charge by measuring the counterweights in a beam balance necessary to keep such a balance in equilibrium.

COULOMB'S CONTRIBUTION

THE ADVANCE OF THE STUDY of electricity was in direct proportion to the ability of investigators to identify and measure its manifestations. The most important contribution to the art of measuring an electrostatic charge was accomplished by Charles A. Coulomb (1736-1806), trained as a military engineer, whose deeper interests in electrical phenomena grew out of his work after he returned from a tour of duty in the colony of Martinique. He had settled in Paris and had applied himself to the problems of strength of materials, friction, torsion, rigidity, and plasticity. His reports won him a prize and membership in the Academy of Sciences. His interest then turned to the problems posed by the Academy in which a prize was offered for the best design for a ship's compass. Toward the solution of this problem, Coulomb applied principles he had studied while investigating the properties of materials, especially torsional rigidity.

In about 1784, he constructed the torsion balance, one of the prime instruments in electrical science. The instrument consisted of a glass cylinder shown in Fig. 3, marked *A B C D*, about the circumference of which were marked graduations in degrees. The cylinder was covered by a round glass disc having one hole in its center and another at the side. Above the center hole projected a slender cylinder upon the top of which rested a graduated torsion micrometer *op*, and suspended centrally from this was a fine silver wire *qP*. This wire could be zeroed by turning the top torsion-head. At the

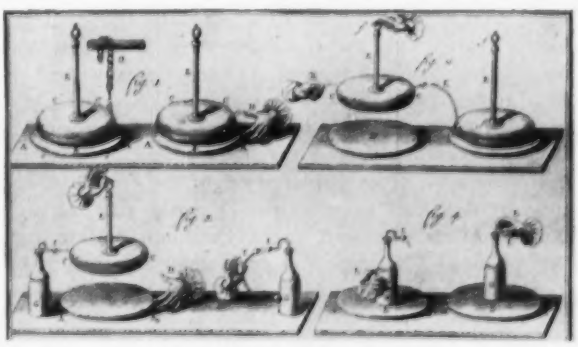

Fig. 2. Volta's electrophorus.

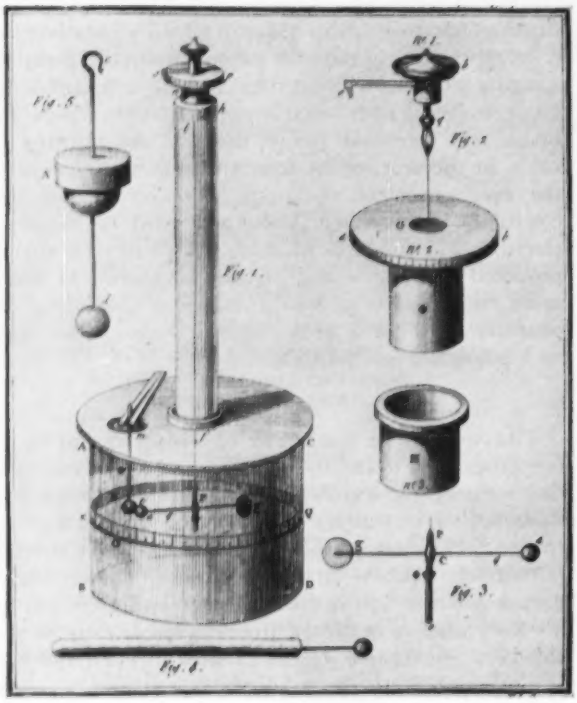

Fig. 3. Torsion balance instrument built by Coulomb.

lower end of the suspended wire, there was attached a horizontal reed or stiff silk thread, reinforced by a sealing-wax coating. The reed had a pith ball *a*, attached to one end, and a small paper disc *g*, set radially at the other end. The disc acted as a counterpoise to the ball and also served to dampen reed oscillations. As shown in the parts detail at upper left, a second pith ball, rigidly suspended by an insulating seal, was lowered into the second hole *m*, in order to be near the first ball.

The functioning of the instrument depended on the principle first enunciated by Coulomb, that by similarly charging the two pith balls a repulsion force caused a twist of the wire that gave rise to a restoring couple measurable by the angle of displacement twist. With the use of extremely fine wire, Coulomb made his instrument sensitive to a force equivalent to only 0.0005 dyne, and even more sensitive with the use of a silk fiber. In an experiment published in 1785, Coulomb set the torsion-head at zero reading, then twisted the head to bring the free ball to touch the fixed ball; both were then charged and the free ball moved around 36 degrees. Coulomb turned the torsion-head to bring the ball through half its displaced angle and found he had to twist the head 144 degrees. To bring the ball to a quarter of its displaced angle, Coulomb had to turn the top head 576 degrees or four times as much as before. He thereupon concluded, from these ratios, that the repellent force between two similarly electrified spheres was inversely proportional to the square of the distance between their centers, the basic law of electrostatics. Coulomb devised other methods of proving the same inverse square law as valid for electrostatic attraction.

The experimental proof of the inverse square law in electrical attraction and repulsion was demonstrated by Priestley, and later in an unpublished paper by Henry Cavendish (1731-1810), in London, from the deduction that a charge upon the conductor resided entirely upon its surface. Using a globe covered with tinfoil and fitted into two hemispheres which he closed upon the globe, Cavendish charged the hemispheres and connected them momentarily to the inner globe. He then separated the hemispheres and found the inner globe completely discharged. Coulomb also, independently of Cavendish, devised a sphere and hemispheres to demonstrate the distribution of a charge upon a conductor.

Meticulous in his method and thorough in procedure, Coulomb was the last of the great experimenters in the first phase of the electrical era, a period that covered the two centuries between Gilbert's work and the opening of new vistas made possible by Volta's discovery of electrochemical, constant-current generation. It was in part because of the development of delicate detection and measuring instruments that it became possible for Volta to notice the minute electric charges, developed by the contact of dissimilar metals, that guided him to the development of the voltaic pile.

In the 60 centuries covered by records of scientific attainment, only one event—the formulation of geometry by the Greeks—compares in brilliance with electrical discovery. These key achievements were two millennia apart; both occurred in societies active with the ferment of inquiry and intellectual boldness. There probably is no ecstasy to equal that of the Greek geometer who defined his problem and then could write "Q.E.D." to its resolution. So it must have been with Cavendish and his discharged sphere that proved the

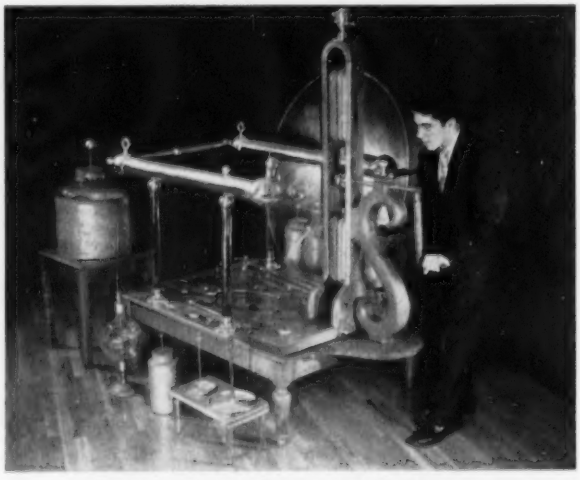

Fig. 4. An electrical machine used by De Saussure in his experiments. In addition to the apparatus shown, a drawer within the base contains 25 connected Leyden jars. This machine is now in the Burndy Library, Norwalk, Conn.

"inverse square law" for electric charges. Surely no pain was so welcome as the spark that struck Franklin's knuckle to bear the new knowledge that lightning and electricity were of one nature.

The early electricians were men driven by an urge to understand the new phenomena that their machines indicated. The efforts of some were recognized and rewarded by their contemporaries. A few resolved their problems to their own satisfaction. None could have realized the great benefits that would be endowed upon mankind by the patient experimenting, the analysis of the results, and the communication of their discoveries. Much honor is due them, and some is also reserved for the communities that fostered their investigations and encouraged their work.

REFERENCES

In addition to the direct reference sources listed in the text itself, other sources from which most of the preceding material was derived are here listed.

1. The Intellectual Rise in Electricity (book), P. Benjamin. London 1895. A critical history from the ancients to Franklin, pp. 600.

2. Benjamin Franklin's Experiments (book), I. B. Cohen. Harvard University Press, Cambridge, Mass. 1941. (Includes an introduction to the early history of electricity.)

3. The Two Hundredth Anniversary of Benjamin Franklin's Two Lightning Experiments and the Introduction of the Lightning Rod, *Proceedings*, American Philosophical Society, June 20, 1952, pp. 36. (Covers the rod and kite literature and controversies.)

4. Galvani–Volta (book), Bern Dibner. Burndy Library, Norwalk, Conn., 1952, pp. 52. (The controversy that led to the discovery of the voltaic cell.)

5. The Founding Fathers of Electrical Science (book), Bern Dibner, Burndy Library, Norwalk, Conn., 1954, pp. 48.

6. Commentary of the Effects of Electricity on Muscular Motion (book) Luigi Galvani. Norwalk, Conn., 1953. (Contains the early history of electricity by Dr. I. B. Cohen.)

7. A Source Book in Physics (book), William F. Magie. McGraw-Hill, New York, N.Y., 1953, pp. 290. (Magnetism and electricity, extracts from original text.)

8. Sparks, Lightning, Cosmic Rays—An Anecdotal History of Electricity, D. C. Miller, New York, 1939, pp. 192. (Prepared from lectures for bright young people.)

9. Bibliographical History of Electricity & Magnetism (book), P. F. Mottelay, Griffin, London 1922. (A comprehensive chronological analysis of the literature in this field to 1821.)

10. Makers of Electricity (book), Brother Potamian, J. J. Walsh. Fordham University Press, New York, N. Y., 1909, pp. 404. (Peregrinus to Kelvin.)

11. Catalogue of the Wheeler gift, Brother Potamian. New York, 1909. (Describes the Latimer Clark collection presented to the AIEE, listing and describing, among others, over 6,500 books and pamphlets on electricity and magnetism prior to 1800.)

12. The Development of the Concept of Electric Charge (book), Duane Roller, D. H. D. Roller, Cambridge, Mass., 1954, pp. 97.

13. Catalogue of Books and Papers Relating to Electricity, Magnetism, the Electric Telegraph etc. (book), Francis Ronalds, E. Spon, F. N. Spon, London 1880, pp. 564. (One of the most complete catalogs.)

14. The Flight of Thunderbolts (book), B. F. J. Schonland, Oxford, England, 1950, pp. 152. (A study of the history and conquest of lightning.)

15. Soul of Amber, the Background of Electrical Science (book), M. A. Still. Murray Hill Books, Inc., New York, N. Y., 1944, pp. 274.

16. A History of the Theories of Aether and Electricity (book), E. T. Whittaker. Philosophical Library, London 1910, new edition 1951; pp. 475.

17. A History of Science, Technology and Philosophy in the 16th and 17th Centuries (book), A. Wolf. Macmillan, London, England, vol. I, 1950.

18. A History of Science, Technology and Philosophy in the 18th Century (book), A. Wolf. Macmillan, London, England, vol. II, 1952.

Research Projects Survey of the Electric Utility Industry

H. P. SEELYE
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The results of a broad survey conducted by the EEI of research projects now under way in the utility field are presented. Data will be used to co-ordinate research efforts among member companies.

THE ELECTRIC POWER INDUSTRY, like most other great modern industries, has been developed on a firm basis of research. Its remarkable history of growth and progress could only have been possible by the continued application of research to the discovery and improvement of methods of generating electric power, of transmitting it to customers, of utilizing it by the customers, and also of management, finance, and all of the other necessary components of the power business. The power load has doubled about every 10 years for the past three decades and yet power has been provided wherever and whenever it was requested by the users, in ample amounts and of excellent quality. It is obvious that this accomplishment could have been made only by forward thinking and creative action backed by adequate research.

Both utilities and equipment manufacturers have, of course, participated in this research. Each has done a

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great deal independently and a large amount has also been co-operative, in one way or another. Any question of whether the share assumed by either was too great or too little is immaterial. The necessary results have been accomplished and the cost, of course, borne by the ultimate power consumers through their purchase of power, to their own great benefit and economic advantage. The same conditions evidently apply to the extensive research activities which are now going on and which will continue in the future.

EEI ACTIVITIES IN RESEARCH

RESEARCH IN THE ELECTRIC UTILITY INDUSTRY has naturally been a matter of import to the Edison Electric Institute (EEI), it being the association of most of the privately owned power utilities in the country. For a great many years, the EEI has sponsored or contributed to certain research programs which have seemed to be of particular significance and of general interest to the industry. At present there are 10 such programs under way. There has, however, been no concentrated, centrally directed general program by the Institute, most of the research having been carried out by its member companies individually or in small groups.

An increasing trend in requests for Institute sponsorship of a variety of specific research proposals led to the appointment of the Research Projects Committee by the EEI board of directors about five years ago. This committee was charged with the screening of research projects currently proposed by the various EEI committees and other outside organizations, and with the promotion of suitable research offering promise of direct benefit to the electric utility industry.

As one phase of the work of this Research Projects Committee, a survey of the research work now under way or recently completed by EEI and its member companies was initiated. It was believed necessary to obtain by this means more complete information on the amount and status of actual present research activities before any further effort toward co-ordination or expansion could be considered. The author of this article was engaged as a consultant to conduct this survey, and active work on it began about July 1956.

CONDUCT OF SURVEY

THE EXPRESSED OBJECTIVES of this research survey are as follows: (1) determine the amount and type of research now being considered or sponsored by EEI member companies, and also more important projects since 1950; (2) promote the exchange of information between companies in regard to their present research activities and the results therefrom, in order to obtain the greatest benefits and to minimize duplication of research effort; and (3) secure favorable publicity as appropriate and in good taste, to emphasize the scope, importance, and results of research work sponsored by the electric power industry.

One of the first necessities was to set up a definition of "Research." Obviously, there could be very many different concepts of what might be included, ranging all the way from a limitation merely to studies of fundamental natural laws and phenomena, up to a broad inclusion of everything in the nature of studies, investigations, tests, trials, etc. Naturally, it was necessary to draw some lines, but at the same time it was desirable to include any projects which would contribute to the general purpose of finding out what the industry was doing in this field.

A definition was selected as follows: "Any organized original investigation into new materials, new equipment, new processes or new methods not previously used, both in engineering and also in other fields." The key words in this definition are "organized," "original," and "new." They exclude casual, indefinite, or incidental consideration of ideas, and mere trials or tests of developed devices or equipment. It was further stipulated that the projects should have general interest to the industry, and not be merely of local significance. Study of the unknown or unrecognized characteristics or possible applications of already developed materials or equipment, establishment or clarification of basic principles, and comprehensive compilations of facts or data were also allowed.

The company membership of EEI, which includes about 175 operating utilities, was canvassed with a request that each appoint a correspondent who would represent his organization in giving and receiving information on this survey. The response was excellent, 111 correspondents being named, representing 132 companies, some of them serving groups of allied companies. Most of those not responding were relatively small companies from whom little research would be expected. These correspondents were requested to submit lists of all research projects which they had under way or in which they were directly participating, including those recently completed. The definition established and also a set of explanatory criteria were furnished as guides in selecting those projects which should be included. Again, the response was gratifying.

The lists, when received, were processed by screening out any items which did not seem to meet the criteria and by re-wording the statements if necessary, to obtain some degree of consistency and uniformity. The revised lists were returned to the correspondents for approval and correction. The resulting projects were transcribed to a card file, duplications assembled, and the whole sorted into a detailed subject classification. The projects sponsored by or supported by EEI as a whole or by its major committees were also added.

RESULTS OF SURVEY

THE TOTAL NUMBER of research projects reported was 968. Most of these are being carried out within the utilities' own organizations, but also a substantial part is assigned to university and other research organizations.

After deducting duplications (more than one company working on identical subject) and groups of items very similar in nature or on different phases of the same

subject, a total of 763 distinct subjects remained. These items were classified as follows:

Power Plants	229
System Planning, Engineering, and Operation	75
Transmission and Distribution	302
General Engineering Items	35
Customers' Utilization	34
Sales	11
Economic Subjects	23
Company Management Subjects	14
Electronic Computers	2
Personnel	19
Area Development	19
TOTAL	763

Space does not permit giving here the detailed subclassification and numbering system used. As might be expected, a number of the items are of a relatively minor nature. On the other hand, each one was screened to have some general interest to the industry and to contain elements of originality and new development. Opinions would vary greatly on just which items should be included in this minor category and, therefore, no attempt was made to eliminate any of them from the list at this time. A scanning by the author indicates that not more than 20% could reasonably be so classed. The remaining 80% range from topics of moderate import to those of very considerable depth and value.

It cannot be claimed that a 100% coverage of the industry was obtained. No doubt, some companies submitted types of items which might be overlooked by others, so that a larger return would be obtained by a second survey. On the other hand, some omissions and further limitations on minor items would also, no doubt, be made. In general, however, it is believed that returns were obtained from practically all of the utility companies which are engaged in significant research and that the subjects listed, both large and small, are representative of most of the work which is being done. Of the total correspondents participating, 47 reported no projects (other than participation in atomic power development groups on the part of 16 of these), 26 listed from 1 to 5 projects, so that the greater activity is found among the remaining 38 organizations, which, of course, include most of the larger companies.

EXAMPLES OF SUBJECTS LISTED

IT IS IMPOSSIBLE to quote any substantial number of the projects in this article. A selected list of some of the more significant topics covered, however, is as follows:

Atomic Power. This subject is, of course, the predominant single item. Sixty-nine electric utility companies, either individually or as part of organized groups, are participating in 14 nuclear reactor projects. Seven of these projects are either under construction or in the immediate preconstruction phase, while the other 7 are in various stages of planning. Several other groups and individual utilities are carrying on studies of various kinds in this field.

Hydro Plant. Effect of cloud seeding on water supply; and evaporation from lake surfaces.

Steam Plants. Combustion problems of various kinds; sulphur removal from stack gas; stack design; air pollution; economic use of fly ash; feedwater analysis and treatment; extension of Steam Tables to higher temperatures and pressures; super-critical steam generation; quick starting of turbine-generators; and gas turbines.

System Planning, Engineering, and Operation. Load forecasting; service standards; economic distribution voltages; system load dispatching; extra-high-voltage transmission, both overhead and underground; lightning and lightning protection; voltage flicker; thermal characteristics of soils; and noise in plants, stations, and equipment.

Transmission and Distribution. Use of plastics in cable joint insulation; use of aluminum for cable conductors and sheaths; use of fiber glass for poles and insulators; behavior of aluminum conductor connectors; wood pole life and preservation; corrosion and corrosion protection on both overhead and underground structures; transformer loading; fault location; relaying; and metering.

Customers' Utilization. Load characteristics for industrial equipment and for general groups; farm electrification; air conditioning; heat pump applications; heat storage; and steel production.

Sales. General promotion of use of power; and industrial development.

Economic Subjects. Costs; annual charges; and revenue forecasts.

Company Management Subjects. Business organization; management guide; economic indexes; and cost of money.

Electric Computers. Possible application of computers to utility problems.

Personnel. Selection, evaluation, attitudes, communications, health.

Area Development. Natural resources, water conservation, minerals, agriculture.

SUMMARY

IT SEEMS EVIDENT from the results of this survey that the electric utility industry is carrying on a very substantial amount of research and cannot be accused of being laggard in this respect. Certain improvements might, of course, be suggested. No doubt, many subjects could be added, and also, no doubt, will be as time goes on. Just what the future program may be cannot be stated at this time. This survey indicates good opportunities for exchange of information, greater coordination of effort, and broadening of scope. The Research Projects Committee in its continuing program will naturally give attention to these possibilities.

Logarithmic-Diode Count-Rate and Period Meter

BRUCE B. BARROW

THE DESIRE to achieve safe automatic start-up of nuclear power reactors—especially where rapid starting of marine or airborne reactors is required—has led to attempts to measure transients in neutron flux at power levels that correspond to 10^{-10}, or less, of full operating power. At these levels, one uses instruments such as counters and count-rate meters, that operate on individual neutron detections. Logarithmic count-rate meters are frequently used for convenience in monitoring wide ranges of neutron flux. Furthermore, the variable most commonly used for control during reactor start-up is the time derivative of the logarithm of the neutron flux, which is by definition proportional to the reciprocal of the period.

For purposes of analysis, the two essential elements of a logarithmic-diode count-rate meter are a capacitor and a two-terminal device (the diode) that produces a voltage proportional to the logarithm of the current passing through it. These two elements are connected in parallel and receive as an input a series of current pulses (uniform in size) that result from the detection of individual neutrons within the reactor by means of some device such as a fission counter. Because the neutron detections occur randomly in time, however, the measured counting rate fluctuates. Increasing the shunt capacitance makes the instrument less responsive to the random "bunching" of neutron detections, which produces spurious short-term changes in measured count rate, but it likewise leads to more sluggish response when the meter encounters a true change in count rate. Achieving the optimum balance of adequate smoothing and sufficiently rapid transient response is the core of the design problem, both for the count-rate meter and for the related period meter, which is merely a logarithmic count-rate meter followed by a linear electrical differentiating circuit.

The nonlinear differential equation expressing the voltage across a shunt combination of logarithmic diode and capacitor can be solved for a specified form of current input. Two cases have been studied in detail. The first concerns the transient behavior of the count-rate meter and period meter when supplied with a continuous-current input, i.e., with an input transient that does not include the statistical effects of the randomly occurring neutron detections. The second case considers the random effects observed when the flux level of a reactor is constant. Furthermore, the superposition of the two results is justified in the cases of practical interest, so that one can design for the realistic case in which flux transients occur but have to be measured in spite of interference from random effects.

Because the log-diode meter is nonlinear, not all transient responses to a step change in period have the same shape. Increasing the speed of a transient, or lowering the level from which it begins, causes a more distorted response that requires a greater number of elapsed periods before settling out. Although the transients during an actual reactor start-up involve changing periods, it is easy to apply the results of the simpler analysis to determine whether the capabilities of the period-measuring system would be exceeded for an arbitrary flux transient.

The study of the statistical effects caused by the random nature of the neutron-detecting process can be handled most easily, and with negligible error, if the log diode is replaced by its equivalent incremental resistance. Then it is possible to apply conventional techniques of random-process theory for linear networks.

Insofar as operation at a constant flux level is concerned, the most interesting property of the log-diode count-rate meter is that the magnitude of the voltage fluctuations at the output is independent of count rate (although the rapidity of the fluctuations increases with increasing count rate). Inasmuch as the output voltage is a measure of the logarithm of the count rate, it follows that this circuit estimates all count rates to within the same percentage accuracy.

The nonlinear analysis shows that the results of the statistical study are applicable during flux transients which are slow enough to be followed accurately. On this basis, the results of the transient analysis and the statistical analysis can be superposed for any transient that the log-diode count-rate meter could handle in the absence of any random effects whatever.

The differentiating network required to convert a logarithmic count-rate meter into a period meter must perform two functions: it must differentiate the slower transients in count rate in order to measure period, and it must filter the rapid transients that result from random effects and represent spurious indications of reactor flux. The required network is, thus, a particular type of narrow bandpass filter.

Two fundamental limitations restrict the useful range of the log-diode period meter. First, the logarithmic portion of the characteristic curve for present thermionic diodes does not greatly exceed five decades of current, and existing semiconductor diodes have less range. Second, even with fast fission counters, the loss of counts at count rates higher than about 100,000 per second becomes excessive. Within these restrictions, however, it is possible to build a log-diode period meter that will safely control start-up at periods of between 10 and 20 seconds.

Digest of paper 57-403, "The Logarithmic-Diode Counting-Rate Meter and Period Meter," recommended by the AIEE Committee on Nucleonic and Radiation Instruments and approved by the AIEE Technical Operations Department for presentation at the 2nd Nuclear Engineering and Science Conference, Philadelphia, Pa., Mar. 11-14, 1957. Scheduled for publication in AIEE *Communication and Electronics*, Sept. 1957.

Bruce B. Barrow is with Hycon Eastern, Inc., Cambridge, Mass.

Magnetic Output Amplifiers for Digital Control

ANDRESS KERNICK
ASSOCIATE MEMBER AIEE

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ASSOCIATE MEMBER AIEE

WITH THE ADVENT of power-frequency magnetic-amplifier devices for logic systems, a need has developed for 10 to 1,000 volt-ampere output magnetic amplifiers conrolled by 0.1 to 1 volt-ampere logic signals. Digital output requirements are particularly stringent because the amplifier is adapted to complete, existing lines of transducer devices (e.g., solenoid valves, power contactors, small motors, etc.) intended to operate from a power line directly or through a step-down transformer where flat (0 to 5%) voltage regulation is demanded of the amplifier, although instantaneous load variation may be as great as 20 to 1 between transient and steady-state conditions.

Introduction of positive current feedback or negative voltage feedback from output to input permits design of magnetic amplifiers that are thermally limited to small steady-state loads, but twentyfold momentary output can be delivered by these amplifiers at the required 5% voltage regulation. Conventional nonfeedback circuits, meeting the load transient at similar voltage regulation, result in excessively large amplifiers which exhibit less power gain and slower response[1] from a given signal. Supply voltage to feedback amplifier gate windings is deliberately made higher than in conventional circuits to permit regulation of output to nearly constant voltage required by surge loads. Regulatory feedback by either closed-loop voltage control or open-loop current compensation provides balance of output droop tendency by approach toward full reactor saturation.

The voltage-feedback system possibly offers better response to the actuated state, as its voltage tends to be excessive because of transient lag. Current-feedback systems are slightly slower in "on" response, inasmuch as load current must be established before full output can be realized. Ability of the open-loop scheme to follow load-current change is inherently good, and good compensation for droop in output voltage as a function of load current on a transient basis should be more readily obtained. Increase of coil impedance with electromagnet armature attraction produces desirable cancellation of velocity compounding that reduces wear at critical closed gaps over the unshaded armature pole face. The best scheme must effect control of the amplifier most quickly. In the closed-loop voltage-feedback circuits, close control that is required invites instability problems due to gain and time constants involved.

Fig. 1 discloses a novel circuit having four saturable magnetic cores for actuation of digital loads. Two prominent difficulties usually present in feedback circuits are overcome: (1) the entire slope of the input–output transfer characteristic of only the auxiliary reactors is used, thus some means to limit the region of control exists; (2) independence of the regulation characteristic from control ampere-turns alleviates critical nature of bias and control settings. Sufficient control ampere-turns are provided to drive the main reactors to saturation when the load is to be actuated. Feedback turns on the auxiliary reactors drive them to saturation on maximum inrush load current, but auxiliary-reactor bias ampere-turns regain control on steady-state load.

Empirically, a maximum of 25% of the gate-supply voltage, dropped across the auxiliary-reactor gate winding, has not proved excessive, as determined by negligible increase in electromagnet armature hum from waveform distortion during steady-state "on" condition.

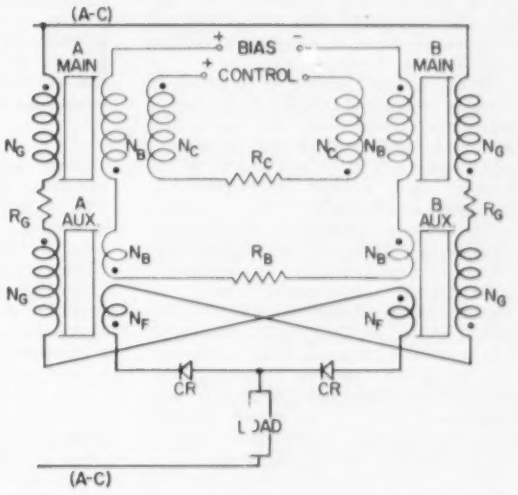


Fig. 1. Load-controlled magnetic amplifier.

Segregation of main-reactor control from the open-loop feedback to auxiliary reactors makes performance of logic functions (AND, NOT, OR, and MEMORY[2]) manageable in the amplifier, as well as many other types of diversified control.

REFERENCES

1. The Influence of Magnetic Amplifier Circuitry upon the Operating Hysteresis Loops, H. W. Lord. AIEE *Transactions*, vol. 72, pt. I, 1953 (Jan. 1954 section), pp. 721-28.

2. Magnetic Amplifiers for Replacement of Relays, R. J. Radus, R. W. Roberts, O. R. Rieley, C. V. Fields. *Proceedings*, National Electronics Conference, Inc., Chicago, Ill., vol. 12, 1956.

Digest of paper 57-774, recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Communications and Electronics*, 1957.

Andress Kernick and H. A. Perkins, Jr., are with the Westinghouse Electric Corporation, Pittsburgh, Pa.

INSTITUTE ACTIVITIES

Once Again Chicago Will Be Host to the Fall General Meeting of AIEE

FOR THE FOURTH YEAR in succession, the Fall General Meeting of the AIEE will be held in Chicago, Ill. This year, the meeting will be held October 7-11, and the headquarters will again be at the Morrison Hotel. The technical program, inspection trips, and social activities will occupy the entire facilities of the Morrison during the five-day meeting.

Chicago is the center of one of the greatest diversified industrial areas in the world and its easy accessibility by air, rail, and automobile from all parts of the continent makes it an unusually favorable place for this important meeting.

At the General Session to be held on Monday afternoon, October 7, the Members-for-Life Fund Medal for outstanding service as a teacher in Electrical Engineering Education will be awarded to W. L. Everitt, dean, College of Engineering, University of Illinois.

On Thursday, October 10, in the beautiful Terrace Casino of the Morrison Hotel, the Sperry Award for developing the Diesel-Electric Locomotive will be awarded to H. L. Hamilton, R. M. Dilworth, and E. W. Kettering at a luncheon scheduled for 12 noon. The award will also go to the Controls, Electrical Engineering, Locomotive, and Mechanical Engineering Sections of the engineering department of the Electromotive Division of the General Motors Corporation.

Tables of 6, 8, or 10 will be reserved when ordered in this manner by groups or organizations. Individual ticket purchasers will be taken care of on a first come, first served basis. The cost of the luncheon is $5 per person. Tickets and reservations may be procured from E. H. Finch, c/o Sargent and Lundy, Engineers, 140 South Dearborn, Chicago 3, Ill.

Technical Sessions

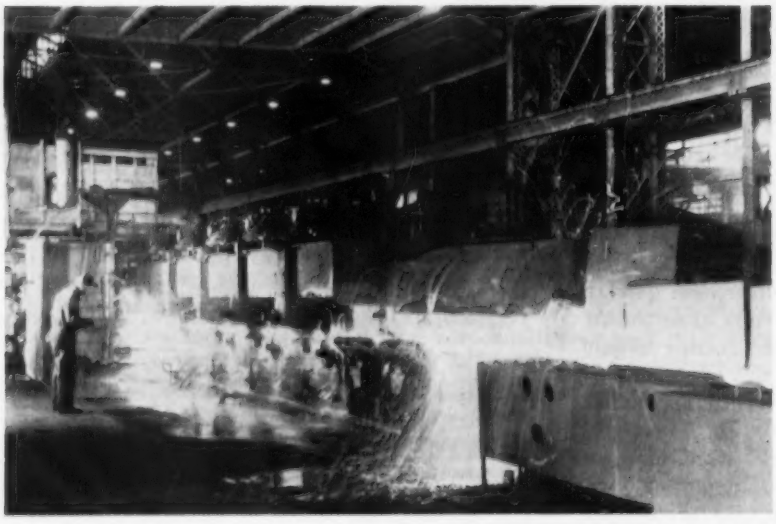
A large and varied technical program has been planned with special attention being given to the subject of Computing Devices, Transmission and Distribution, and Communication. Two sessions of note will be on Nuclear Reactors. The subject of Shopping Center Distribution will be covered in a separate session. Sessions also are scheduled by the General Committees on Education and Safety.

Social Activities

Social activities will begin on Sunday afternoon, October 6, from 4 to 6 p. m., with an informal reception tea, and with a hospitality hour sponsored by the Chicago Section, AIEE, for members of the AIEE and their families.

The Fall Frolics will be held on October 9 in the Terrace Casino of the Morrison Hotel. Tickets for this event went on sale September 1. It looks as though it will be a sell-out so orders should be sent in early.

Last Fall, the party was a gay and colorful affair. An excellent floor show after dinner is in store and dancing will follow. Dress will be informal. The tickets will be $11 each or $22 per couple. Send a check for tickets to: M. J. O'Laughlin, Southerland Engineers, 222 W. Adams, Chicago 6, Ill.



ON THURSDAY AFTERNOON, during the AIEE Fall General Meeting, an inspection trip will be held to the Chicago Plant of the Youngstown Sheet and Tube Company to view the process of making steel.

Ladies' Activities

In addition to the daily 9 a.m. coffee hour during the meeting, the women will be entertained at a variety of events. Following is a list and description of each event:

Sunday: Reception in the Cotillion Room in the Morrison Hotel, 4 to 6 p.m.

Monday: Afternoon, Dessert Card Party in the Ladies' Headquarters in the Walnut Room. This is sponsored by the Delta Star Company.

Tuesday: Luncheon in the Pump Room of the Ambassador East Hotel. Dorothy Bond, a syndicated cartoonist, will speak and also will do some caricatures of a few in the audience attending the Luncheon. This Luncheon is being sponsored by the Allis-Chalmers Manufacturing Company.

Wednesday: Brunch in the Cub Room of the Morrison Hotel. Betsy Ross, a well-known decorator from the John A. Colby Company, will speak on Interior Decorating. There will be a $3 charge for the Brunch.

Thursday: Luncheon in the Crystal Room of the Chicago Athletic Club. Sulie Harand, a well known entertainer, will give a musical play. This luncheon is being sponsored by Westinghouse Electric Corporation.

Friday: Program ends with the morning coffee hour.

Radio, Television, Theater Tickets

Free radio and television tickets for all days of the convention will be available. Tickets should be secured a day in advance and information concerning programs, show times, and seating will be available at Headquarters.

Theater tickets and tickets for sporting events will be available only from the hotel ticket broker in the lobby.

Hotel Reservations

Leo Dolkart is in charge of Hotel Room Reservations and should be contacted in case assistance is needed. Address requests to Leo Dolkart, Hotel Room Reservations Committee, 222 E. Chestnut St., Chicago 11, Ill.

It is suggested that in order to secure good accommodations, reservation and rate cards be mailed as soon as possible directly to the Morrison Hotel. If they are mislayed or lost, write to the Reservation Manager, Morrison Hotel, Madison and Clark Sts., Chicago 2, Ill. Be sure in making requests for reservations to mention the AIEE Meeting.

The Morrison Hotel has set aside a large number of rooms for this General Meeting. If it is decided at the last minute to attend, there is still a good chance that rooms will be available at this hotel.

(Continued on page 898)

AIEE Fall General Meeting, Chicago, Ill., October 7-11, 1957

Tentative Technical Program

Monday, October 7

9:00 a.m. Industrial Power Systems

57-1021. Criteria for Industrial Application of Single-Phase Transmission Lines, 400 to 20,000 Cycles. *W. A. Munson, A. J. Germain,* Westinghouse Electric Corporation

CP57-1022. Basic Considerations of D-C Power System Design. *W. A. Munson,* Westinghouse Electric Corporation

CP.* 400-Cycle Electrical Distribution Systems for Power or Lighting. *D. L. Johnson,* General Electric Company

CP.* Testing the Adequacy of Industrial Power Distribution Systems. *A. Durand, D. Dalasta*

9:00 a.m. Power Reactor Instrumentation

CP.* Argonne Low-Power Reactor Instrumentation Design. *H. H. Hooker,* Argonne National Laboratory

CP.* Problems in Reactor Instrumentation for the Experimental Breeder Reactor No. 2. *A. Lovoff, J. R. Simanton,* Argonne National Laboratory

CP.* On the Application of a Direct Energy Balance Instrumentation System for Power Reactors. *R. N. Brey, R. H. Morse,* Leeds and Northrup

CP.* Reliability of Instruments Power Supply for Reactors. *John Parnell, C. W. Sundin,* Minneapolis-Honeywell Regulator Company

CP.* Major Design Concept of the Instrumentation for the Country's First Privately Financed Atomic Power. *E. P. Diehl,* General Electric Company

9:00 a.m. Power Systems Communications

57-1091. Protection Equipment for Power Company Communication Lines. *D. L. Brown, L. N. Sherban,* Portland General Electric Company

CP57-1092. Fully Automatic Dialing System for Two Canadian Power Utilities. *Otto Kreis,* Brown Boveri (Canada) Ltd.

57-1093. Coupling Methods for Power Line Carrier Systems. *D. E. Jones,* Hydro Electric Power Commission of Ontario

9:00 a.m. Ethics

CP.* Professional Conduct—The Activities of Other Organizations in This Field and Their Relation to AIEE. *P. L. Alger*

CP.* Professional Code of Ethics for Recruiting. *E. L. Overt,* American Society for Engineering Education

9:00 a.m. Semiconductor Circuits

CP.* Thermal Stability of Junction Transistors and Its Effect on Maximum Power Dissipation. *H. C. Lin*

57-1023. A Generalized Theory of Transistor Bias Circuits. *Herbert Hellerman,* University of Delaware

CP57-1024. Shunt Feedback in Transistor Amplifier. *R. J. Patch,* General Electric Company

CP57-1025 Graphical Analysis of Transistor Switching Circuits. *M. Rubinoff, A. Messey, H. Yamada,* University of Pennsylvania

*Conference Papers will not be printed by the Institute; however, they may be available at the meeting at the discretion of the author.

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CP57-1026. Transistorized Television Vertical Deflection System. *W. Palmer, G. Schiess,* Sylvania Electric Products, Inc.

2:00 p.m. General Session

Welcoming Address: T. G. Ayers, vice-president, Commonwealth Edison Company

Response: W. J. Barrett, president, AIEE

Presentation of AIEE Medal in Electrical Engineering Education to W. L. Everitt, dean, College of Engineering, University of Illinois

Address: R. W. Galvin, president, Motorola, Inc.

Tuesday, October 8

9:00 a.m. Symposium on Electric Supply to Large Shopping Centers

CP57-1072. Electric Supply to Detroit Area Shopping Centers. *W. E. Groves,* The Detroit Edison Company

CP57-1073. Electric Service to Shopping Centers on Virginia Electric and Power Company's System. *R. C. Daffron,* Virginia Electric and Power Company

CP57-1071. Electric Service Supply to Roosevelt Field Shopping Center. *R. M. Grogan,* Long Island Lighting Company

CP.* Supply to Large Shopping Areas in the Chicago Metropolitan Area. *W. R. Zimmerman,* Commonwealth Edison Company

9:00 a.m. Switchgear

57-727. Severe Rates of Rise of Recovery Voltage Associated with Transmission Line Short Circuits. *W. F. Skeats, C. H. Titus, W. R. Wilson,* General Electric Company

57-1032. 4,160-Volt, 350-Mva. Metal-Clad Switchgear with Symmetrical Rating. *E. B. Rietz, G. O. Perkins, W. A. Carter,* I-T-E Circuit Breaker Company

57-1031. An Outdoor Metal-Clad Switchgear Unit with a Weather-Protected Operating Aisle. *H. B. Wortman,* Westinghouse Electric Corporation

CP57-1049. Airblast Circuit Breaker Characteristics. *W. O. Rowan,* The Hydro-Electric Power Commission of Ontario

9:00 a.m. Rotating Machinery

CP57-1005. A Modified Adjustable Speed Brushless Induction Motor. *A. M. El Gammal,* Ain Shams University

57-1003. Simulation of the Operational Impedances of Synchronous Machines on Network Analyzers. *Colin Adamson, A. M. S. El-Serafi,* Manchester College of Science and Technology

57-1006. Gas Flow and Heat Transfer in Conductor Cooled Machines. *L. T. Rosenberg,* Allis-Chalmers Manufacturing Company

57-1004. A Variable Speed D-C Motor Drive Employing the Xatron, a Grid Controlled Mercury Arc Rectifier. *A. J. Humphrey, K. L. Shrider,* Reliance Electric and Engineering Company

9:00 p.m. Television and Aural Broadcasting

CP57-1007. Color and Monochrome Cathode Ray Tube Performance Tests. *C. F. Otis,* Philco Corporation

CP.* Prediction and Measurement of the Coverage of a Television Station. *D. W. Peterson,* RCA Laboratories

CP.* Status Report on Video Tape Applications in Broadcasting. *H. A. Chinn,* Columbia Broadcasting System Television

CP.* A Radiating System for Television Broadcasting. *Andrew Alford, Harold Leach,* Alford Manufacturing Company

9:00 a.m. General Circuit Theory

57-1027. Small Signal Heterodyne Mixers with Excessive Injection Potentials. *J. F. Cline,* Stanford Research Institute

CP57-609. Amplitude and Frequency Stabilization of an Oscillator Using Nonlinear Elements. *C. J. Triska,* Iowa State College of Agriculture and Mechanical Art

CP57-1028. The Diode Reactance Modulator. *G. F. Montgomery,* National Bureau of Standards

57-1029. A Nonlinear Low-Frequency Instability Phenomenon in Audio Amplifiers. *Theron Usher, Jr.,* Yale University

CP57-1030. Equivalent Circuits of Noisy Networks. *Leo Young,* Westinghouse Electric Corporation

2:00 p.m. Nuclear Reactors

57-1068. Load Control for the Shippingport Nuclear Power Station. *H. A. Van Wassen,* Duquesne Light Company

57-1069. Engineering Design of the EBWR Facility. *D. C. McClintock,* Sargent and Lundy

CP.* EBWR Nuclear Design and Power Station Operating Experience. *J. M. Harrer*

2:00 p.m. Rotating Machinery

57-1008. Analog Computer Study of Wind Tunnel Drive. *K. G. Black, R. J. Noorda,* General Electric Company

CP.* A Theory for Shaded-Pole Motors. *F. W. Suhr,* General Electric Company

CP* Switching Voltages of Induction Motors. *E. C. Schrom.*

CP.* Switching Transients in Small Motors. *R. K. Drake, S. A. Zimmermann*

2:00 p.m. Television and Aural Broadcasting

CP.* The Television Allocations Study Organization—Its Origin, Objectives, and Progress. *G. R. Town,* Executive Director, TASO

CP.* The Systems Approach to the Determination of Television Coverage. *R. H. Bowie,* Sylvania Electric Products, Inc.

CP.* Summary of Performance Characteristics of Television Receiving and Transmitting Equipment. *W. J. Morlock*, General Electric Company; *W. D. Swinyard*, Hazeltine Research, Inc.

CP.* The Measurement of Television Field Intensities and the Relationship between Field Intensity and Picture Quality. *H. T. Head*, A. D. Ring and Associates

2:00 p.m. Safety

CP57-1009. The Scope and Limitation of Cardiac Resuscitation. *A. S. Gordon, M.D., Ph.D.*, University of Illinois, College of Medicine

CP57-1010. The Adjunctive Use of Mechanical Resuscitation in Electrical Contact Accidents. *T. M. G. Martin*, University of California

CP57-1011. The Principles and Practice of Emergency Mechanical Resuscitations. *C. W. Frye, M.D.*, University of Illinois; *A. S. Gordon, M.D.*, University of Illinois

CP57-1012. A Comparison of Mouth-to-Mouth and Manual Artificial Respiration Techniques. *A. S. Gordon, M.D.*, University of Illinois; *C. W. Frye, M.D.*, University of Illinois, College of Medicine

CP.* A Demonstration of Artificial Respiration. *A. S. Gordon, M.D., and others*, University of Illinois, College of Medicine

2:00 p.m. Graduate Honors Co-operative Program

Wednesday, October 9

9:00 a.m. Metallic Rectifiers

CP57-1046. III-V Compound Rectifiers. *G. B. Kich*, Fansteel Metallurgical Corporation

CP.* Gallium Arsenide Phosphide PHN Junctions. *G. A. Jenny*, Radio Corporation of America

CP57-1047. Structure and Characteristics of SiC Light-Emitting Junctions. *Lyle Patrick*, Westinghouse Electric Corporation

CP.* Preparation of Silicon Carbide, Single Crystal and Use in Rectifiers. *L. Kroko, H. Chang*, Westinghouse Electric Corporation

CP57-1048. Anodized Titanium-Solid Lead Peroxide Rectifier. *Samuel Ruben*, Ruben Laboratories

9:00 a.m. Symposium on Substations and Electric Service

CP.* How Substation Design and Operation Reflect Customer Service Continuity Requirements. *L. M. Olmsted*

CP* Corrosion in Substation Grounding. *P. M. Black*

9:00 a.m. Computing Devices

57-1053. The Transformer Analog Computer. *P. Venkata Rao, G. Krishna*, Institute of Science

CP.* Some Aspects of the Reliability of Analog-to-Digital Conversion. *A. Yeiser*, Applied Electronics Laboratories

CP.* Digital Camera Coder for Spatial Angles. *J. S. Ward*, Massachusetts Institute of Technology

57-684. Analog Computer Study of the Transient Performance of a Dual Cycle Boiling Water Reactor Nuclear Power Plant. *D. W. Leiby*, General Electric Company

57-685. A Rolling Mill Analog for the Study of Nonlinear Problems Associated with Gauge Control.

9:00 a.m. Communication Theory

CP.* The 'Megacoder'—A High-Speed Large-Capacity Microminiature Decoder for Selective Communication. *Harry Kihn, W. E. Barnette*, RCA Laboratories

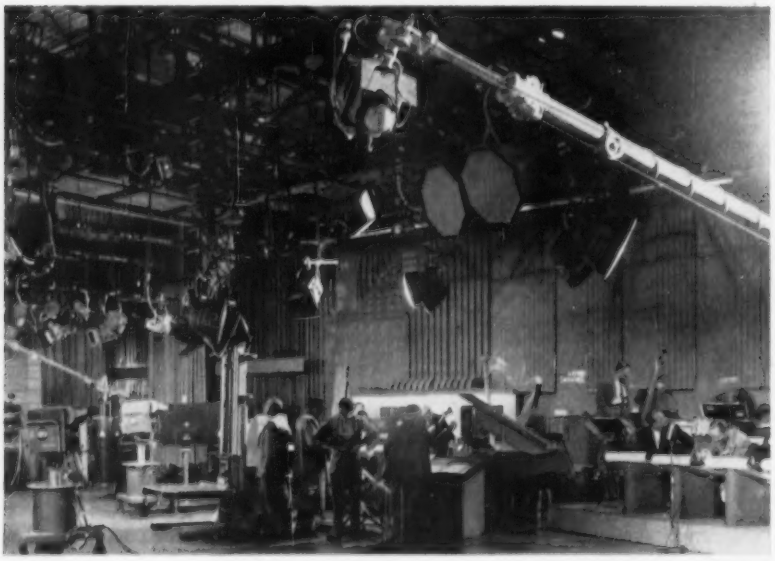
CP57-1041. Binary Symmetric Decision Feedback Systems. *Bernard Harris, K. C. Morgan*, New York University

57-1042. Kineplex, A Bandwidth Efficient Binary Transmission System. *R. R. Mosier, R. G. Clabaugh*, Collins Radio Company

CP.* An Experimental Study of a Binary Code. *W. W. Peterson*, University of Florida

9:00 a.m. Power Generation

Panel Discussion—"The Relation of Automatic Transfer of Steam Station Auxiliaries to Station Protection"



PARTIAL VIEW of Studio 1, WBBM-TV, Columbia Broadcasting System (CBS), Chicago, Ill. The final inspection tour of the Fall General Meeting will be to the new headquarters and broadcasting facilities of CBS.

TOD Forum at Chicago

Featured at the Forum of Technical Committee chairmen, vice-chairmen, and their deputies at the Hotel Morrison, Chicago, Ill., on the evening of Wednesday, October 9, will be all-Divisional participation in a panel discussion moderated by Hendley Blackmon, chairman of the Technical Operations Department (TOD). The subject will be: "What You Should Watch Out For as a Technical Committee Chairman." Questions and comments from the floor will be invited on the assigned subtopics: making recommendations for committees and subcommittees, handling and programming papers for General and District Meetings, special technical conferences, running a committee meeting or serving as chairman of a session, deadlines, and forecasts and statistics.

CP57-1094. Special Features of 5,000-Kw EBWR Turbine Condenser and Pump. *C. H. Morris, K. H. Gruenwald, C. E. Kenny*, Allis-Chalmers Manufacturing Company

9:00 a.m. Feedback Control Systems

57-1033. The Selection and Use of Servo Performance Criteria. *W. C. Schultz, V. C. Rideout*, University of Wisconsin

57-1036. Extended Switching Criterion for Second Order Saturated Servomechanisms. *J. N. Diesel*, Washington University

CP57-1035. Analyses of Servomechanisms by Describing Function Method on a Plane with Parameters as Co-ordinates. *Toshio Numakura, Takeo Miura, Akira Kamoi*, Hitachi Central Research Laboratory

2:00 p.m. Symposium on Substations and Electric Service

CP.* Highside Protection of Substation Transformers without Breakers and Fuses. *O. J. Rotty*

CP.* Voltage Regulation for Substations. *H. F. Barsun*

2:00 p.m. Transmission and Distribution

57-1074. Economics of System Conversion from 27.6-Kv to 33-Kv Operation. *H. K. Amchin, T. May, T. J. Nagel*, American Gas & Electric Service Corporation

57-1075. Unbalanced Loading of Three-Phase Transformer Banks—II Economics. *S. W. Anderson*, Middle West Service Co.

57-1076. Combined Single-Phase and Three-Phase Loading of Open-Delta Transformer Banks. *H. M. Bankus, J. E. Gerngross*, General Electric Company

2:00 p.m. System Engineering

57-1054. Kilovar Supply in Bulk-Power Transmission Systems. *J. M. Henderson, H. O. Simmons, Jr., J. B. Tice*, General Electric Company

57-1101. A New Approach to Loss Minimization in Electrical Power Systems. *J. F. Calvert, T. W. Sze*, The University of Pittsburgh

57-1055. Rapidly Converging Digital Load Flow. *R. H. Jordan*, Indianapolis Power and Light Company

CP57-1056. Extensions in Digital Flow Techniques Using High Speed Computer. *M. S. Dyrkacz, A. F. Glimn, D. G. Lewis*, General Electric Company

(Continued on page 897)

MEETING	DESIGNATION	NAME OF MEETING	CONVENTIONAL SCHEDULE	1958			1959			1960			1961			1962			INVITATIONS	
				DATE	LOCATION	PAPER CLOSING	DATE	LOCATION	PAPER CLOSING	DATE	LOCATION	PAPER CLOSING	DATE	LOCATION	PAPER CLOSING	DATE	LOCATION	PAPER CLOSING	DATE	LOCATION
GENERAL	WG	WINTER	JAN 4 TH WK	FEB 2-7	NEW YORK N.Y.	OCT 14 1957	FEB 1-6	NEW YORK N.Y.	OCT 14 1958	JAN 31 FEB 5	NEW YORK N.Y.	OCT 14 1959	JAN 29 FEB 3	NEW YORK N.Y.	OCT 14 1960	JAN 28 FEB 2	NEW YORK N.Y.		63	1/27-2/1 NEW YORK
																			64	2/2-2/7 N.Y.
																			65	1/31-2/5 OR 2/7-2/12
	SG	SUMMER	JUNE 3 RD 4 TH WK	JUNE 22-27	BUFFALO N.Y.	MAR 14 1958				JUNE 19-24	ATLANTIC CITY N.J.	MAR 11 1960	JUNE 18-23	ITHACA N.Y.	MAR 10 1961	JUNE 17-22	DENVER COLO		63	TORONTO
							JUNE 21-26	SEATTLE WASHINGTON	MAR 13 1959										64	LOS ANGELES
	PG	PACIFIC	AUG.	AUG 19-22	SACRAMENTO CALIF.	MAY 9 1958				AUG 8-12	SAN DIEGO CALIF	APR 29 1960	AUG 23-25	SALT LAKE CITY, UTAH	MAY 15 1961				63	SPOKANE, WASH.
	FG	FALL	OCT.	OCT 26-31	PITTSBURGH PA	JUNE 27 1958	OCT 11-16	CHICAGO ILL.	JUNE 12 1959	OCT 9-14	CHICAGO ILL.	JUNE 10 1960	OCT 15-20	DETROIT, MICH	JUNE 16 1961		CHICAGO, ILL.		64	CLEVELAND
DISTRICT	D1	EMPIRE	EARLY MAY		(SGM)		APR 29 MAY 1	SYRACUSE N.Y.	JAN 19 1959											
	D2	MIDDLE EASTERN	MAY	APR 28-30	WASHINGTON DC	JAN 17 1958	MAY 19-21	BALTIMORE MD.	FEB 6 1959		(SGM)		MAY 2-4	PITTSBURGH PA	JAN 20 1961	MAY 14-16	ERIE, PA.			
	D4	SOUTHERN	LATE MAR EARLY APR				APR 8-10	ATLANTA GA.	DEC 27 1958				APR 5-7 OR 12-14	NEW ORLEANS LA.	JAN 2 OR 9					
	D5	GREAT LAKES	LATE APRIL	MAY 5-7	M.S.U. E.LANSING MICH	JAN 24 1958														
	D7	SOUTH WEST	LATE MAR. EARLY APR	MAR 31 APR 2	TULSA, OKLA	DEC 20 1957														
	D11	EAST CENTRAL	EARLY MAY	MAY 13-15	HUNTINGTON W VA	JAN 31 1958	MAY	AKRON OHIO		MAY	CHARLESTON W VA		MAY	CLEVELAND, OHIO		MAY	TOLEDO, OHIO			
	D12	NORTH EASTERN								MAY	PROVIDENCE, R.I.									
EASTER				APRIL 6			MARCH 29			APRIL 17			APRIL 2			APRIL 22				

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

T.O.D. SUBCOMMITTEE ON MEETING SCHEDULES

1958 - 1962

SCHEDULE OF

GENERAL & DISTRICT MEETINGS

ISSUED BY:

J. D. TEBO

CHAIRMAN

ISSUE NO:

DATE:

DWG. NO.

AIEE Future Meetings

AIEE-IRE-IIT-NU-U of I National Electronics Conference*
Hotel Sherman, Chicago, Ill.
October 7-9, 1957

Fall General Meeting*
Morrison Hotel, Chicago, Ill.
October 7-11, 1957

Reliability and Quality Control in Electronics Conference*
Silver Spring, Md.
October 10, 1957

AIEE-IRE-ASME Feedback Control Systems Conference*
Chalfonte-Haddon Hall Hotel
Atlantic City, N. J.
October 16-18, 1957

Farm Electrification Conference*
Hotel Nicolett
Minneapolis, Minn.
October 29-31, 1957

EJC-ECPD Engineers General Assembly
Hotel Statler, New York, N. Y.
October 24-25, 1957

EMC of EJC-SMC-NSF-NAS-NRC-WSE Engineering and Scientific Education Conference
Edgewater Beach Hotel
Chicago, Ill.
October 31-November 2, 1957

Machine Tool Conference*
Hotel Schroeder
Milwaukee, Wis.
November 4-6, 1957

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference*
Harvard University
Boston, Mass.
November 6-8, 1957

Mid-Atlantic Textile Conference*
North Carolina State College
Raleigh, N. C.
November 14-15, 1957

Magnetism and Magnetic Materials Conference*
Park Sheraton Hotel
Washington, D. C.
November 18-21, 1957

AIEE-IRE-ACM Eastern Joint Computer Conference
Park Sheraton and Shoreham Hotels
Washington, D. C.
December 9-13, 1957
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Oct. 4)

AIEE-IRE-ASQC Reliability and Quality Control Conference
Statler Hotel
Washington, D. C.
January 6-8, 1958
(Final date for †TP—closed, ‡CP Syn.—Oct. 22, CPMs—Nov. 1)

AIEE-IRE Scintilation Counters Conference
Shoreham Hotel
Washington, D. C.
January 27-28, 1958
(Final date for †TP—Oct. 18, ‡CP Syn.—Nov. 12, CPMs—Nov. 22)

Winter General Meeting
Hotel Statler, New York, N. Y.
February 2-7, 1958
(Final date for †TP—Oct. 14, ‡CP Syn.—Nov. 1, CPMs—Nov. 5)

AIEE-IRE-U of P Transistor and Solid State Circuits Conference
Philadelphia, Pa.
February 20-21, 1958
(Final date for †TP—Nov. 8, ‡CP Syn.—Dec. 3, CPMs—Dec. 13)

Textile Conference
Georgia Institute of Technology
Atlanta, Ga.
March 13-14, 1958
(Final date for †TP—Dec. 3, ‡CP Syn.—Dec. 26, CPMs—Jan. 7)

American Power Conference
Sherman Hotel, Chicago, Ill.
March 17-19, 1958
(Final date for †TP—Dec. 6, ‡CP Syn.—Jan. 1, CPMs—Jan. 10)

EJC Nuclear Congress
International Amphitheatre
Chicago, Ill.
March 17-21, 1958
(Final date for †TP—Dec. 6, ‡CP Syn.—Jan. 1, CPMs—Jan. 10)

Pulp and Paper Conference
North Carolina State College
Raleigh, N. C.
March 27-29, 1958
(Final date for †TP—Dec. 20, ‡CP Syn.—Jan. 15, CPMs—Jan. 24)

South West District Meeting
Tulsa, Okla.
March 31-April 2, 1958
(Final date for †TP—Dec. 20, §DP Syn.—Jan. 10, DPMs—Jan. 13)

AIEE-ASME Railroad Conference
Cleveland, Ohio
April 9-10, 1958
(Final date for †TP—Dec. 30, ‡CP Syn.—Jan. 24, CPMs—Feb. 3)

AIEE-IRE-ASME Automatic Techniques Conference
Statler Hotel
Detroit, Mich.
April 14-16, 1958
(Final date for †TP—Jan. 3, ‡CP Syn.—Feb. 25, CPMs—Feb. 7)

Middle Eastern District Meeting
Washington, D. C.
April 28-30, 1958
(Final date for †TP—Jan. 17, §DP Syn.—Feb. 7, DPMs—Feb. 11)

Great Lakes District Meeting
Michigan State University
East Lansing, Mich.
May 5-7, 1958
(Final date for †TP—Jan. 24, §DP Syn.—Feb. 7, DPMs—Feb. 11)

AIEE-IRE-ACM Western Joint Computer Conference
Ambassador Hotel
Los Angeles, Calif.
May 6-8, 1958
(Final date for †TP—Jan. 24, ‡CP Syn.—Feb. 18, CPMs—Feb. 28)

East Central District Meeting
Huntington, W. Va.
May 13-15, 1958
(Final date for †TP—Jan. 31, §DP Syn.—March 7, DPMs—March 11)

AIEE-IRE-RETMA-WCEMA Joint Electronic Components Conference
Los Angeles, Calif.
May 21-23, 1958
(Final date for †TP—Feb. 14, ‡CP Syn.—March 11, CPMs—March 21)

AIEE-ISA-IAS National Telemetering Conference
Baltimore, Md.
May, 1958

Domestic Appliances Conference
Hotel Morrison, Chicago, Ill.
May 27-29, 1958
(Final date for †TP—Feb. 14, ‡CP Syn.—March 11, CPMs—March 21)

Summer General Meeting
Buffalo, N. Y.
June 22-27, 1958
(Final date for †TP—March 14, ‡CP Syn.—April 4, CPMs—April 7)

AIEE-IRE Nonlinear Magnetics and Magnetic Amplifiers Conference
Los Angeles, Calif.
August 6-8, 1958
(Final date for †TP—April 25, ‡CP Syn.—May 20, CPMs—May 30)

Pacific General Meeting
Sacramento, Calif.
August 19-22, 1958
(Final date for †TP—May 9, ‡CP Syn.—June 5, CPMs—June 6)

Petroleum Industry Conference
Baker Hotel, Dallas, Texas
September 15-17, 1958
(Final date for †TP—June 6, ‡CP Syn.—July 1, CPMs—July 11)

Fall General Meeting
Pittsburgh, Pa.
October 26-31, 1958
(Final date for †TP—June 27, ‡CP Syn.—Aug. 1, CPMs—Aug. 8)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
§DP Syn.—District Synopsis
DPMs—District Manuscript

(Continued from page 894)

2:00 p.m. Land Transportation

2:00 p.m. Feedback Control Systems

CP57-578. Servo Control System for a Large Optical Tracking Instrument. *M. H. Mehr,* The Perkin-Elmer Corporation

CP57-1037. Analysis of Multiple Sampler Systems with Finite Pulse Width (Open Loop). *G. Farmanfarma,* University of California

CP57-1034. Stability Study of a Third-Order Servomechanism with Multiplicative Feedback Control. *Y. H. Ku,* Moore School of Electrical Engineering; *C. F. Chen,* Christian Brothers College

Thursday, October 10

9:00 a.m. Transmission and Distribution

57-1087. 1956 Lightning Field Investigation on the OVEC 345-Kv System. *R. H. Schlomann, W. S. Price,* American Gas and Electric Service Corporation; *I. B. Johnson,* General Electric Company, New York, N.Y.; *J. G. Anderson,* General Electric Company, Pittsfield, Mass.

57-1084. Lightning Performance of 138-Kv Twin Circuit Transmission Lines of Commonwealth Edison Company Operating Experience and Field Studies. *R. W. Caswell, E. F. Koncel, Jr.,* Commonwealth Edison Company; *I. B. Johnson, N. R. Schultz,* General Electric Company

57-1085. Field Studies of the Surge Response of a 345-Kv Transmission Tower and Ground Wire. *G. D. Breuer, A. J. Schultz, R. H. Schlomann, W. S. Price,* General Electric Company

57-548. An Approximate Transient Solution of the Tapered Transmission Line. *L. O. Barthold,* General Electric Company

57-1086. Analytical Studies on Lightning Phenomena Involving Towers, Insulator Strings, and Transmission Lines. *I. B. Johnson, A. J. Schultz,* General Electric Company

9:00 a.m. Power Generation and System Engineering

57-1064. Minimization of Fuel Costs by the Technique of Linear Programming. *A. P. Hayward, C. E. Taylor,* Duquesne Light Company; *R. H. Kerr, L. K. Kirchmayer,* General Electric Company

57-1065. Economic Considerations in Generation Scheduling Southwestern Public Service Company System. *R. W. Thomas,* Southwestern Public Service Company; *L. K. Kirchmayer,* General Electric Company

CP57-1066. Basic Data for Load Schedule Development. *F. H. Light, Sr.,* Philadelphia Electric Company

CP57-1067. Determination of the Incremental Heat Rate Characteristic by Performance Testing. *R. W. Thomas,* Southwestern Public Service Company

9:00 a.m. Wire Communications

CP57-1016. Transistorized Negative Impedance Telephone Repeaters. *R. P. Dimmer,* Automatic Electric Company

57-391. The Application of Negative Impedance Repeaters on Long Rural Telephone Lines. *H. T. Uthlaut, Jr.,* Southern Bell Telephone & Telegraph Company

CP57-1097. A Miniaturized Negative Voice Repeater Employing Transistors. *A. S. Howell,* Stromberg-Carlson Telephone Company

CP.* A Study of Negative Impedance Loading. *D. F. Hoth,* Bell Telephone Laboratories

9:00 a.m. Mining and Metal Industry

CP.* Standardization of Cables and Hose Conduits of Mine Motors and Controllers. *J. Tindall,* Reliance Electric and Engineering Company

CP.* Sequence Control of Mining Belt Conveyors. *Ben Harbage,* Jeffrey Manufacturing Company

CP.* Pioneering Carrier Communications and Controls in Mines and Mills. *W. P. Place,* FEMCO Inc.

CP.* Current Carrying Capacity of Portable Cables on Reels. *John McNiff, A. H. Shepherd,* Simplex Wire and Cable Company

9:00 a.m. Transformers

CP57-1038. The Significance of Transformer Functional Testing to the Operating Company. *A. M. Lockie,* Westinghouse Electrical Corporation

57-1039. The Effect of Transformer Oil Preservation Methods on the Dielectric Strength of Oil. *R. B. Kaufman, J. L. Pierce, E. R. Uhlig,* General Electric Company

CP.* Rapid Spot Test Methods for the Evaluation of Used Transformer Oil. *R. E. Reinhard, W. E. Elliott,* Allis-Chalmers Manufacturing Company

2:00 p.m. Computing Devices

57-1061. Statistical Design Theory for Strictly Digital Sampled Data Systems. *S. S. L. Chang,* New York University

CP57-1062. Russian to English Machine Translation with Simple Logical Processing. *R. E. Wall, Jr.,* University of Washington; *U. K. Niehaus,* Boeing Airplane Company

CP57-1063. Random Access and the Manufacturing Control Problem. *C. A. R. Kagan,* Western Electric Company, Inc.

57-673. Matrix Analysis of Logical Networks. *E. J. Schubert,* Westinghouse Electric Corporation

57-677. Cycle and Delay Time Considerations in a Real-Time Digital Computer. *Herbert Freeman,* Sperry Gyroscope Company

2:00 p.m. Transmission and Distribution

57-1077. Suspension Insulator Flashover under High Impulse Voltages. *B. E. Kingsbury,* General Electric Company

57-1078. Impulse Flashover Characteristics of Long Strings of Suspension Insulators. *A. F. Rohlfs, H. E. Fiegel,* General Electric Company

57-1079. Factors Affecting the Lightning Performance of Transmission Lines. *J. H. Hagenguth, J. G. Anderson,* General Electric Company

57-1080. A Hypothesis Concerning Lightning Phenomena and Transmission Line Flashover. *I. B. Johnson, A. J. Schultz,* General Electric Company

CP57-537. Calculation of Transmission Line Lightning Voltages by Field Concepts. *R. Lundholm,* Chalmers Tekniska; *R. B. Finn, Jr., W. S. Price,* American Gas and Electric Service Corporation

2:00 p.m. Power Generation and System Engineering

CP.* Determination of Incremental Heat Rate Characteristics from Operating Records. *V. R. Peterson, A. H. Willennar,* American Gas and Electric Service Corporation

CP57-1058. Practical Limitations in the Determination of the Incremental Cost of Fuel. *E. K. Corporon,* Interchange Power Services, Inc.

CP57-1059. The Effect of Fuel Heating Value on the Economic Loading of Power Systems. *W. H. Guppy,* Commonwealth Edison Company

57-1060. Incremental Maintenance Costs of Steam-Electric Generating Stations. *M. J. Steinberg,* Consolidated Edison Company of New York, Inc.

Round Table Discussion—"Application of Incremental Heat Rates to Automatic Load Dispatching"

2:00 p.m. Communication Switching Systems

57-1019. A Numerical-Graphical Method for Synthesizing Switching Circuits. *A. H. Scheinman,* Bell Telephone Laboratories, Inc.

CP57-1020. Automatic Mobile Telephone System. *R. P. Dimmer*

CP.* Mechanization of Toll Switching in Providence, R. I. *C. W. Anderson,* New England Telephone and Telegraph Company

2:00 p.m. Mining and Metal Industry

CP.* Factors Affecting Rating of Mine Motors. *L. L. Lipanye,* Reliance Electric and Engineering Company

CP.* Wired Vision and Pushbutton Control. *E. A. Berry,* Mine Safety Appliances Company

CP.* Electrical Problems Involved in Designing Fluorescent Mine Lighting Systems. *R. S. James,* U. S. Bureau of Mines

2:00 p.m. Transformers

57-530. Orthomagnetic Current Transformers for Laboratory and Factory Testing. *L. W. Marks, G. Camilli,* General Electric Company

57-1040. A Way to Get Low Sound Levels in Large Power Transformers—Preassembled Enclosures. *M. W. Schulz, Jr., W. J. McNutt,* General Electric Company

CP.* Standard Basic Impulse Insulation Levels. Report by AIEE Standards Co-ordinating Committee No. 8

2:00 p.m. Wire Communications

CP57-1070. Filter Design for Transistorized Carrier. *T. Winkler,* Stromberg-Carlson Company

57-1017. Mechanical Features of 561 Subscriber Carrier. *J. E. Ross, O. H. Goldman,* Stromberg-Carlson Company

57-1018. Engineering Features and Field Trial Performance of a New Subscriber Carrier Systems. *R. L. Layburn,* Stromberg-Carlson Company

57-786. A Review of Telephone Development in Western Europe and in Underdeveloped Areas. *G. D. Wallenstein,* Lenkurt Electric Company

CP.* New Design Approaches for Military Carrier Equipment. *Neale Zellmer, William Luchter,* Lenkurt Electric Company

Friday, October 11

9:00 a.m. Transmission and Distribution

57-1081. Ground Fault Location Indicator. *A. C. Lee,* Northern States Power Company

57-1082. Transmission Line Tower Footing Design. *L. B. LeVesconte, W. C. Freeman, R. L. Reese,* Sargent and Lundy

CP57-1083. Correct Aluminum Connector Designs Eliminate Need for "Pressure Maintaining Devices." *M. R. Monashkin,* Burndy Corporation

9:00 a.m. Electronic Transformers

57-1013. Size Reduction of Airborne Transformers. *R. E. Lee,* Westinghouse Electric Corporation

57-1014. Standards for High Voltage, High Power Rectifier Transformers. *J. J. Halloran,* Electro Engineering Works

CP.* Bridge Method for Pulse Measurements on Miniature Transformer Core Materials. *A. D. Furbee,* General Electric Company

CP57-1015. Design of Random Noise Transformers. *M. P. Vore,* Westinghouse Electric Corporation

CP.* Design Considerations for Dry-Type High-Voltage Power Supplies for Electrostatic Processes. *E. C. Hill,* General Electric Company

9:00 a.m. New Concepts in the Application of Insulation and AIEE No. 1

CP57-1088. Revision of Standard No. 1. Report of Co-ordinating Committee No. 4 of the Standards Committee, AIEE

CP57-1089. The Guides for Thermal Evaluation of Insulating Materials and Systems, AIEE No. 1D and 1E. *G. L. Moses,* Westinghouse Electric Corporation; *J. F. Dexter,* Dow Corning Corporation

CP57-1090. International Activities in the Temperature Classification of Electrical Insulating Materials. *L. J. Berberich,* Westinghouse Electric Corporation

2:00 p.m. Radio Communications

57-1044. 6,000 Megacycle/Sec. Radio Relay System for Broad Band Long Haul Service in the Bell System. *M. B. McDavitt,* Bell Telephone Laboratories, Inc.

CP.* Radio Multiplex with Circulators. *L. B. Johnson,* Lenkurt Electric Company

CP.* Single Sideband for Mobile Applications. *H. Magnuski, W. Firestone, R. Richardson,* Motorola

CP57-1045. Unattended Recording of VHF Receiver Site Noise. *R. E. Bloor,* Ohio Telephone Company

CP.* Evaluation of 900 Megacycles as a Potential Vehicular Communication Band. *C. J. Schultz*

2:00 p.m. Industrial Control

CP.* Automation Applied to a Structural Mill. *S. A. DeCaro,* United States Steel Corporation

CP.* Factors Influencing Control Desk Design. *D. E. Strom,* United States Steel Corporation

CP.* Improved Safety in the Control of Stamping Presses. *B. H. Carlisle, T. N. Anderson,* Clark Controller Company

CP57-1043. A Photoelectric Device Using a Radioactive Source. *P. Weisman, S. L. Ruby,* Westinghouse Electric Corporation

2:00 p.m. Chemical Industry

CP57-1052. New Developments in Cathodic Protection. *B. Husock,* Harco Corporation

2:00 p.m. Insulated Conductors

57-1050. A Study of the Superposition of Heat Fields and the Kennelly Formula as Applied to Underground Cable Systems. *C. A. Bauer, R. J. Nease,* Commonwealth Edison Company

57-1051. Cable Tunnel Crossings. *E. J. Dawson,* Commonwealth Edison Company; *R. W. Gillette,* Consolidated Edison Company; *A. F. Corry,* Boston Edison Company

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(Continued from page 892)

Definite rooms will not be reserved until members arrive. If rooms at rates requested are not available, a room will be assigned at the next higher rate available.

Please indicate on reservation card the time of arrival. This is necessary if arriving after 6 p.m. A room will be held for such a member, no matter what time after 6 p.m. he may arrive. Payment for this night will be charged to such a member.

If correspondence with the hotel regarding room reservations is necessary, please mail a copy of the letter to Mr. Dolkart so that matters can be expedited. The Morrison Hotel will acknowledge all room reservations. If an acknowledgement is not received after a reasonable time, write to the hotel, sending a copy to Mr. Dolkart.

Inspection Trips

Eight separate trips have been arranged for AIEE members attending the Fall General Meeting.

Tuesday Morning: Electro-Motive Division of General Motors will be host for a tour through their facilities at La Grange, Ill. In addition to the tour of the manufacturing facilities for diesel locomotives, guests will be given a demonstration of the Electro-Motive mobile diesel-electric generating units called Electro-Mobile Power. The units are designed to boost power in fringe areas of utility systems and to meet peak load demands.

Tuesday Afternoon: A tour to three of the Chicago area's most modern shopping centers will provide a look at the latest electrical service facilities for this type of application. The shopping centers are the Hillsdale Shopping Center, Old Orchard Shopping Center, and Cermak-Plaza Shopping Center.

Tuesday Afternoon: At this time Commonwealth Edison will display how they use an electronic computer in preparing nearly 12 million bills annually—approximately 50,000 each day.

Wednesday Morning: A tour of the Argonne National Laboratories features a look at the atomic Experimental Boiling Water Reactor officially dedicated and put "on stream" a few months ago (see cover).

Wednesday Afternoon: Will County Generating Station is the newest generating plant of Commonwealth Edison Company and is the subject for the Wednesday afternoon tour. Located on the Chicago Sanitary and Ship Canal, the station's first two units—each of 160,000-kw net capability—were placed in operation in 1955. The third, a 260,000-kw net capability, was placed in commercial operation in June of this year. The station can now generate enough electricity adequately to supply a city of 800,000 people.

Thursday Morning: Automatic Electric Company has just moved into its new 1,520,000 square foot manufacturing plant in suburban Northlake and the Thursday morning trip will be made through this plant.

Thursday Afternoon: Thursday afternoon's tour will be to the Chicago plant of the Youngstown Sheet and Tube Company to view the processes of making steel.

Friday Morning: The final tour of the Fall Meeting will be to the new headquarters and broadcasting facilities for the Columbia Broadcasting System in Chicago. The new facilities are in a building which formerly housed an ice skating arena but which was completely transformed for its broadcasting duties.

Registration

Members can simplify registration procedure by returning the advance perforated registration card promptly. This registration will include the Fall Frolics, Inspection Trips, and Ladies' Events. This will save time in completing registration details upon arrival at the hotel. The registration fee will be $5 for members and $8 for nonmembers. No fee will be required of student members and immediate families of members.

Committee

The members of the 1957 Fall General Meeting Committee are: General Chairman, G. L. Welch; Vice-Chairman, E. H. Finch; Secretary, F. A. Larson; Treasurer, M. J. Adams; Finance and Budget, C. E. Pigue; Fall Frolics, M. J. O'Laughlin; Tickets, D. W. Gilman; General Session, D. K. Chinlund; Hospitality, D. H. Beal; Ladies' Activities, Mrs. F. W. McCloska; Registration, F. M. Scott; Sale of Papers, F. E. Andrews; Technical Program, C. A. Hatstat; Hotel Arrangements, L. E. Randall; Publicity, J. E. Smith; and Trips and Transportation, J. Agosta.

Three Societies Organize Symposium in Atlantic City

The AIEE Feedback Control Systems Committee with participation by the Institute of Radio Engineers (IRE) Professional Group on Automatic Control and the American Society of Mechanical Engineers-Instruments and Regulators Division is organizing a symposium on the theme of "Computers in Control" at the Chalfonte-Haddon Hall Hotel in Atlantic City, N.J., on October 16-18, 1957. The symposium will emphasize the use of digital and analog computers both as elements of feedback control systems and as utilized in the design of such systems.

Some 35 technical papers by leading scientists in this country and by Prof. J. Tsypkin of The Academy of Science, Moscow, U.S.S.R., Dr. M. Pélégrin of The Ministry of Defense, France, and Dr. Blackman of The Imperial College of Science and Technology, London, England, will be presented.

A portion of the papers to be presented at the conference are available in preprint form from the AIEE; the Proceedings of the conference will be published by the AIEE during the first part of 1958. Conference arrangements have been made by a committee consisting of Harold Chestnut, General Electric Company; E. W. Grabbe, Ramo-Wooldridge Corporation; Adam Kegel, Westinghouse Electric Corporation; John Ragazzini, Columbia University; and E. Mishkin and Chairman J. G. Truxal, both of Polytechnic Institute of Brooklyn.

The tentative technical program follows.

Wednesday, October 16

2:00 p.m. Introductory Session

Chairman: J. G. Truxal, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Welcoming Remarks: Harold Chestnut, General Electric Company

Introduction: Session Chairman

The Role of Digital Computers in Automatic Control. *Marc Pélégrin,* Ministère de la Defense Nationale et des Forces Armées, Paris, France; *F. H. Raymond,* Societe d'Eléctronique et D'Automatisme, Courbevois (Seine), France

Some Problems on the Theory of Discrete Automatic Systems. *J. Z. Tsypkin,* The Institute of Automatics and Telemechanics, The Academy of Science, Moscow, U.S.S.R.

Dynamic Programming and the Computational Solution of Feedback Control Design Problems. *R. Bellman,* The Rand Corporation

Analog-Digital Conversion Techniques. *A. K. Susskind,* Servomechanisms Laboratory, Massachusetts Institute of Technology

6:00 p.m. Cocktail Hour

7:00 p.m. Banquet

Thursday, October 17

9:30 a.m. Computers in Control System Design I

Chairman: E. L. Harder, Westinghouse Electric Corporation

Introduction: Session Chairman

A Computer Combining Analog and Digital Principles for Complex Frequency Network Calculations. *P. F. Blackman,* Imperial College of Science and Technology, London, England

Computer Verification of Steam Generator Instrumentation for a Nuclear Power Plant. *D. P. Waite, E. E. Lynch,* General Electric Company

Analog Representation of Heat Exchange—Application to the Simulation of Heat Exchangers of Nuclear Power Plants. *J. M. Carteron, G. Deloux,* Eléctricite de France, Paris, France

Evaluation of a Turbojet Control on an Engine Simulator. *C. R. Heising,* General Electric Company

A Simulation Technique in the Synthesis of Automatic Flight Control Systems. *Y. Nakada, S. I. Scroggs,* Hughes Aircraft Company

CP57-946. Differential Analyzer Aids Design of Computer Control System for Electric Utilities. *L. K. Kirchmayer,* General Electric Company

9:30 a.m. Sampled-Data Systems

Chairman: J. R. Ragazzini, Columbia University

Introduction: Session Chairman

The Analysis of Digital Systems. *H. A. Helm,* Bell Telephone Laboratories

Signal Flow Techniques for Digital Compensation. *J. M. Salzer,* The Magnavox Research Laboratories

Analog Computer Study of Sampled Data Systems. *H. Chestnut, D. W. Leiby,* General Electric Company

The Synthesis of Computer Limited Sampled Data Control Systems. *A. S. Robinson,* Eclipse-Pioneer Division of Bendix Aviation

Rate Limiting in Incremental Computers. *M. H. Steward,* The Magnavox Research Laboratories

2:00 p.m. Computers in Control Systems

Chairman: E. M. Grabbe, The Ramo-Wooldridge Corporation

Introduction: Session Chairman

Real Time Hybrid Computers for Control Systems. *C. T. Leondes,* University of California

Computer Control Experience Gained from Operation of a Large Combined Analog Digital Computation System. *G. P. West,* The Ramo-Wooldridge Corporation

Compensation of Nonlinear and Time-Varying Systems by Computers. *R. Booton,* Massachusetts Institute of Technology; *A. Rosenbloom,* The Ramo-Wooldridge Corporation

Analysis of an On-Off Digital Control System. *J. S. Mayo,* Bell Telephone Laboratories

The Design of a Digital Computer for an Airborne Control System. *J. T. Caulfield, J. V. B. Cooper, W. R. Maclay, O. B. Shafer,* International Business Machines Corporation

Reduction of Control Loop Errors with a Prediction Computer. *George Axelby, R. H. Plath,* Westinghouse Air Arm Division

2:00 p.m. Computers in Control System Design II

Chairman: H. T. Marcy, International Business Machines Corporation

Introduction: Session Chairman

System Considerations in Computer Control of a Semicontinuous Chemical Process. *T. M. Stout,* The Ramo-Wooldridge Corporation

Airborne Program Computer. *C. F. Coit, T. F. Mahoney,* Raytheon Manufacturing Company

General Synthesis Procedure for Computer Control of Single and Multiloop Linear Systems. *R. E. Kalman, J. E. Bertram,* Columbia University

An Application of Root Locus Analysis to a Closed Loop Linear Control System Incorporating a Human Operator. *J. Rodden, J. E. Mangelsdorf,* Lockheed Aircraft Corporation

The Solution of Differential Equations in the Time Domain. *C. W. Steeg,* Radio Corporation of America; *R. V. Morris,* Massachusetts Institute of Technology

7:30 p.m. Panel Discussion—Fitting Computers into Control Systems

Moderator: H. Chestnut, General Electric Company, General Engineering Laboratory, Schenectady, N. Y.

E. M. Grabbe, Ramo-Wooldridge Corporation, Computer Systems Division, Los Angeles, Calif.
E. L. Harder, Westinghouse Electric Corporation, Analytical Engineering, East Pittsburgh, Pa.
E. W. James, E. I. DuPont, Newark, Del
H. T. Marcy, International Business Machines, Poughkeepsie, N. Y.
J. R. Moore, North American Aviation Autonetics, Downey, Calif.
J. R. Ragazzini, Columbia University, Electrical Engineering Department, New York, N. Y.
J. F. Rientjes, Massachusetts Institute of Technology, Servo Laboratory, Cambridge, Mass.

Friday, October 18

9:00 a.m. Optimum Systems

Chairman: Rufus Oldenburger, Purdue University

Introduction: Session Chairman

Control System Optimization Using Computers as Control System Elements. *L. F. Kazda,* University of Michigan

A Dual-Mode Servomechanism Utilizing Saturation Switching. *H. R. Weed, F. C. Weimer,* Ohio State University

Optimum Response of Discontinuous Feedback Control Systems. *F. W. Nesline, Jr.,* Massachusetts Institute of Technology

Divided Reset Compensation of a Nonlinear Control System. *J. W. McCarthy,* Massachusetts Institute of Technology

Application of a Self Adaptive System to the Control of Airplane Normal Acceleration. *M. F. Marx,* General Electric Company

Closing Remarks: Harold Chestnut, General Electric Company

EJC-ECPD General Assembly To Be Held October 24-25, 1957

A General Assembly including the 25th Annual Meeting of Engineers' Council for Professional Development (ECPD) and the 4th Annual General Assembly of Engineers Joint Council (EJC) will take place at the Hotel Statler, New York, N. Y., October 24-25, 1957.

The tentative program for this joint meeting follows.

Thursday, October 24

Morning—Military Service and Professional Development

Evaluation of military service and its contributions to professional development.

1. The Department of Defense Viewpoint
2. The Appraisal by Engineers with Recent Military Experience
3. Discussion

Luncheon—The Present and Future ECPD and EJC

J. W. Barker, president EJC

M. D. Hooven, president ECPD

Afternoon—The Community College and Technological Education

The role of the two-year post high school curricula in technological education in the next decade

Trends in engineering education and in the demand for technological manpower have given a new dimension in the value of community and junior colleges. Their relation to over-all education problems and the utilization of their graduates will be considered, with a comparative analysis of the relative values of terminal and preparatory programs.

Panel Members: E. K. Fretwell, Jr., Assistant Commissioner for Higher Education, University of the State of New York; Otto Klitgard,

1957-58 AIEE Membership Directory Now Available Only to AIEE Members—Price $2

ALL AIEE officers and committee members have been sent their copies.

While the supply lasts, other interested AIEE members may secure one copy only for their own use by completing the label supplied below and sending it together with their remittance of $2 to AIEE Headquarters, 33 West 39 St., New York 18, N.Y.

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president, New York City Community College of Applied Arts and Sciences.

Silver Anniversary Dinner—ECPD

Speaker: C. E. Davies, secretary, American Society of Mechanical Engineers

Friday, October 25

Morning—The Place of the Engineer in Industrial Management

Programs designed to aid engineers to develop into management

A panel of speakers representing large and small industrial organizations will discuss the need for management training for engineers and outline specific company programs.

Panel Members: F. W. Miller, Yarnell Waring Company; Harry Krieger, Radio Corporation of America; W. E. Mullestein, Lukens Steel Company

Luncheon—The College in Professional and Management Development

Speaker: Dana Young, dean of engineering, Yale University

Afternoon—New Dimensions in Postgraduate Education for the Young Engineer

Trends in combining advanced engineering education with engineering employment

Company training programs and graduate education have long been part of engineering career progression. In recent years, however, new forms have developed to meet new needs. This session will explain these developments.

Panel Members: Paul Hemke, vice-president, Rensselaer Polytechnic Institute; S. Ingram, Bell Telephone Laboratories; E. Weber, Polytechnic Institute of Brooklyn; R. W. Rowsen, Fansteel Corporation

The General Assembly program is an exploration of the essential unity and complementary nature of the goals and purposes of ECPD and EJC. The regular council and committee meetings of ECPD will be held simultaneously with the Assembly program. The General Assembly represents the combination of 17 national engineering groups.

For further information about the General Assembly, contact either ECPD or EJC at 29 West 39th St., New York 18, N. Y.

Radio Astronomy To Be Discussed at 13th Annual NEC

Radio astronomy, an important factor in the International Geophysical Year (IGY) studies, will be the subject of one of two tutorial sessions at the 13th Annual National Electronics Conference (NEC) at the Hotel Sherman in Chicago, Ill., October 7-9.

Three papers dealing with the solar and stellar phenomena aspects of radio astronomy will be presented October 7, according to Program Chairman V. H. Disney, manager of the electrical engineering research department at Armour Research Foundation of Illinois Institute of Technology. The papers will provide electronic engineers and others in related fields a basis for better understanding of research conducted during IGY, he explained.

Speakers at this session, and titles of their papers, will be: R. J. Coates, Naval Research Laboratory, Washington, D.C., "Interpretation of Experimental Results"; J. G. Bolton, California Institute of Technology, Pasadena, "Radio's Contributions to Astronomy"; and A. Maxwell, Harvard Radio Astronomy Station, Fort Davis, Texas., "Solar Emissions from the Sun."

The second tutorial session, titled "Solid State," is planned to inform electrical engineers of new developments in solid-state physics which have promising applications in electronics.

Speakers at this session, scheduled for October 8, and titles of their papers, will be: A. E. Slade, A. D. Little, Inc., Cambridge, Mass., "Superconductivity and Its Applications to Electronic Industry"; H. F. Ivey, Westinghouse Electric Corporation, Bloomfield, N.J., "Electroluminescence"; and K. H. Butler, Sylvania Electric Products, Bayside, N.Y., "Luminescence in Solids."

A total of 94 technical papers providing broad coverage of the latest in electronic research, development, and application, and three luncheon speakers will complete the three-day program.

Technical discussions at the opening day's sessions, Monday, October 7, will include: Morning—transistor circuits, communications, servomechanism applications, audio; Afternoon—semiconductor devices, microwaves, circuits, and radio astronomy.

Topics at the October 8 technical sessions will be: Morning—transistors and transistor applications, microwaves (session II), electronic components, servomechanism theory; Afternoon—solid state, computers, electronic components II, and radar and radio navigation.

On October 9, the sessions will cover: Morning—instrumentation I, electron tubes I, circuit theory, magnetic amplifiers; Afternoon—instrumentation II, electron tubes II, and network synthesis.

A record 245 commercial exhibits will be on display at the conference. Most of the nation's leading electronics manufacturers and research laboratories will be represented, according to B. C. Hawkins, exhibits chairman.

The NEC is sponsored annually by AIEE, Illinois Institute of Technology, Institute of Radio Engineers, and Northwestern and Illinois Universities.

Co-operating institutions are Electrical Industries Association, Society of Motion Picture and Television Engineers, and Michigan State, Purdue, Michigan, Notre Dame, and Wisconsin Universities.

Machine Tool Subcommittee Sponsors 9th Annual Conference

The Ninth Annual Machine Tool Conference, sponsored by the Machine Tool Subcommittee of the AIEE, will be held November 4-6, 1957, at the Hotel Schroeder in Milwaukee, Wis. This year, the conference deals with a variety of problems and solutions of immediate importance; it also looks backward at experience with "stored intelligence" systems, and looks forward toward extended use of "static" systems of control.

Registration fees are as follows: AIEE members—$3.00, Student Branch members—free, nonmembers—$5.00. Banquet tickets are $6.00 each, luncheon tickets are $3.50 each, and inspection trip tickets are $1.00 to $2.00 each. Banquet and luncheon reservations deadline is October 28, 1957. Address all reservations other than hotel to: F. L. Fisher, Registration Chairman, c/o Allen Bradley Co., 136 W. Greenfield Ave., Milwaukee 4, Wis. Address hotel reservations to: Hotel Schroeder, 509 W. Wisconsin Ave., Milwaukee, Wis.

The tentative technical program for the conference follows.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

Monday, November 4

8:00 a.m.-Noon Registration

8:30 a.m. Inspection Trips

1. Louis Allis Company inspection tour and luncheon
2. Kearney & Trecker Main Plant inspection tour and luncheon
3. Kearney & Trecker Special Machinery Plant inspection tour

2:05 p.m. Afternoon Session

Welcome: Harry Ankeney, conference general chairman

"Industry's Need for Machine Tool Betterment," William Ryan, president, American Society of Mechanical Engineers

"Engineer of the Future," Ben Elliot, head, mechanical engineering department, University of Wisconsin

Reliability of Electronic Machine Control. General Electric Company

Maintenance Training for Numerically Controlled Machines. *C. E. Losey*, Boeing Airplane Co.

Electronic Maintenance Experience at North American Aviation. *Alan Davis*

Panel Discussion—Machine Tool Path Control from Stored Intelligence

Moderator: George Kinney, Hughes Aircraft Company, chairman American Institute of Aeronautics (AIA) Subcommittee on Machine Tools

Wallace Brainard, Kearney & Trecker Corp.
Len Mautner, Electronic Control Systems, Inc.
Grover Bender, Glenn L. Martin Co.
Murry Kanes, Bendix Aviation Research Laboratory
E. F. Carlberg, Boeing Airplane Co.
John Dutcher, General Electric Company
Bernard Gaiennie, Northrop Aviation
Ken Jensen, Giddings & Lewis Machine Tool Co.
William Webster, Air Materiel Command, USAF, Wright-Patterson Air Force Base
Jack Morgan, Cincinnati Milling Machine Co.

6:30 p.m. Local Industry Cocktail Hour

7:30 p.m. Banquet

Speaker: Lt. Gen. C. S. Irvine, Deputy Chief of Staff, USAF, "The Changing Aircraft Machine Tool Requirement Picture Based on Manufacturing Problems Associated with 'Thermal Barrier' Aircraft and Missile Design"

Tuesday, November 5

9:00 a.m. Morning Session

Point to Point Numerical Positioning Control. General Electric Company

Cost Cutting Experience with New Punch Card Controlled Discrete Positioning Lathe. *Sundstrand*

Precision Measurement Systems. *Farrand*

Automatic Gauging. Pratt & Whitney

Present Metrology Spearheads—Future Automation Growth. *Henry Boppel,* Sheffield Corp.

12:30 p.m. Luncheon

Speaker: W. J. Barrett, president, AIEE. "New Thinking on Organization Policy for the Engineering Profession"

1:55 p.m. Afternoon Session

A Static Proximity Switch for Control Application. *Kenneth Lipman,* Westinghouse Electric Corporation

A Static Press Control. *S. A. Zarleng,* Clark Controller Co.

Panel Discussion—Pancake Type Motors

Moderator: Viljo Hill, Brown & Sharpe Manufacturing Co.

W. T. Nelson, Fairbanks-Morse & Co.
Howell Electric Motors
R. F. Lamkey, Century Electric Motors
Diehl Electric Motors
Vern Honsinger, Allis-Chalmers Manufacturing Co.
W. D. Fournier, Reuland Electric Co.

The New Synduction Motor. *R. Dineen,* Allis-Chalmers Manufacturing Co.

Spindle Motors—Design and Application Experience. *E. A. Kitsch,* Louis Allis Co.

Wednesday, November 6

9:00 a.m. Morning Session

A Static-Magnetic Adjustable Speed Motor Controller. *D. A. Baker,* Cutler-Hammer Co.

Xatron Drive for Machine Tool Applications. *B. B. Finigan,* Reliance Electric Co.

Adjustable Electronic High Powered Machine Tool Drive. *W. S. Harvey,* Raytheon Mfg. Co.

New Adjustable Speed Machine Tool Drive. *Richard Schmitz,* Giddings & Lewis Machine Tool Co.; *A. Mueller, C. E. Quentel,* Square D Co.

An Electronic Feed Drive as Applied to a Horizontal Boring, Milling, and Drilling Machine. *Hugh DePree, P. B. Molstad,* Allen-Bradley Co.

12:15 p.m. Inspection Trips

1. Square D Co.
2. Cutler-Hammer Co.
3. Allen-Bradley Co.

New Officers Announced at Nebraska Section Meeting

At a meeting of the AIEE Nebraska Section held June 20, 1957, at the Hotel Sheraton-Fontenelle, new section officers were announced as follows: Chairman—W. A. Richardson; Vice-Chairman—M. I. Risley; Secretary-Treasurer—P. T. Baird; and Directors-at-Large—H. A. Carlson, R. W. Shaw, J. O. Nelson, P. H. Henson.

During the meeting, Dr. Milo Bail, president of the University of Omaha, gave an interesting talk on the subject of "New Horizons for the Manpower Problem."

Another event of the meeting was a "Fellow Award" ceremony during which A. G. Johnson, vice-president of District No. 6, presented a Fellow diploma to C. L. Sampson.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until October 25. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before October 25.

56-256 **The Lightweight Train—Its Power Supply and Auxiliaries.** *J. L. Swarner*

56-666 **A Magnetic Drum Storage System Considered for Use as a Common Sender in Nation-Wide Dialing.** *H. F. May*

57-76 **An Amplitude-Stabilized Bridged-Tee Oscillator.** *Kurt Enslein*

57-193 **A Differentiator for A-C Computers.** *W. X. Johnson*

57-481 **Some Applications of Magnetic Amplifiers in Aircraft Generator Protective Systems.** *D. L. Plette, J. W. Butler*

57-666 **Video Testing Techniques in Television Broadcasting.** *A. Ste-Marie*

57-678 **The Economics of Component Parts Selection.** *E. F. Fuegel*

57-684 **Analog Computer Study of the Transient Performance of a Dual-Cycle Boiling Water Reactor Nuclear Power Plant.** *D. W. Leiby*

57-703 **A Digital Flying Extensometer for Temper Rolling Mills.** *N. S. Wells*

57-723 **Statistical Encoding for Text and Picture Communication.** *W. S. Michel*

57-745 **Subharmonics in Iron-Cored Reactor Oscillatory Circuits.** *Abd El-Samie Mostafa, M. I. El-Karaksi*

57-767 **The Effective Feedback Factor of Self-Balancing Magnetic Amplifiers.** *W. A. Geyger*

57-773 **A Fast-Response Full-Wave Magnetic Amplifier.** *G. E. Lynn*

57-779 **A Describing Function for the Multiple Nonlinearities Present in Two-Stage Electrohydraulic Control Valves.** *John Zaborszky, H. J. Harrington*

57-780 **Generalized Charts of the Effects of Nonlinearities in Two-Stage Electrohydraulic Control Valves.** *John Zaborszky, H. J. Harrington*

57-795 **Failure Rate Studies on Silicon Rectifiers.** *N. F. Bechtold, C. L. Hanks*

57-907 **A Transistorized Repeater for Use with the 45 BN Cable Carrier System.** *V. Babin, R. Fish*

57-923 **The Block-Diagram Method of Analysis Applied to the Saturable Reactor.** *R. M. Hubbard*

57-991 **Electric Control of Gas Turbines in Gas Transmission Service.** *R. A. Yannone, A. B. Niemoller, F. P. Goertzen*

57-607 **Rating of Autotransformers for System Interconnection.** *E. T. B. Gross, J. E. Pohlman* (the discussion for this paper is due November 20)

Preprints may be purchased at 40¢ each to members 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N. Y.

Proceedings Available of EJC Third General Assembly

The third General Assembly of Engineers Joint Council (EJC) was held January 17-18, 1957, at the Hotel Statler, New York, N. Y. Copies of the Proceedings of this General Assembly may now be obtained from EJC, 29 West 39th St., New York 18, N. Y.; price $1.

Included in the Proceedings are three panel discussions—Problems of the Engineer in Government, The Economic Status of the Engineer, The Impact of the Engineer in International Relations—as well as the speeches delivered at the two luncheons and the Unity Dinner held during the General Assembly.

Prices Changed for *Science Abstracts*

The Institution of Electrical Engineers (IEE), London, England, has announced that the Committee of Management of *Science Abstracts* has decided that, as from January 1, 1958, the price charged to the general public for *Science Abstracts* will be £6.0.0 per annum for Section A, £5 for Section B, and £10 for a combined subscription for both Sections.

The Committee also has decided that the preferential rate of three-quarters of the price charged to the general public should be continued for members of those institutions and societies with which the IEE has reciprocal arrangements. Thus, as from January 1, 1958, prices for AIEE members who subscribe to *Science Abstracts* will be as follows: £4.10.0 per annum for Section A (Physics), £3.15.0 for Section B (Electrical Engineering), and £7.10.0 for both Sections A and B.

Conference To Cover Rural Electrification Advances

Latest advances in rural electrification will highlight the third annual Farm Electrification Conference of the AIEE, to be held in Minneapolis, Minn., October 29-31 with headquarters at the Hotel Nicollet.

This technical conference is being sponsored by the Minnesota Section of the

AIEE and the Farm Electrification Subcommittee of the Domestic and Commercial Applications Committee.

The conference will be addressed by leading representatives from the electrical utilities, equipment manufacturers, rural electrification groups, and other leaders in the farm electrification field.

A highly comprehensive program has been arranged (*Electrical Engineering*, September 1957, p. 814), designed to appeal to all those in attendance. The AIEE has scheduled speakers from various parts of the country to present to the conferees information and advice on newest developments in such important subjects as planning rural distribution systems, rural load characteristics, farm wiring requirements, utilization of electric light, heating and air conditioning for farm production.

According to a spokesman for the AIEE, the Minneapolis conference will cover practically every engineering phase of rural electrification. Papers to be presented will be devoted largely to new developments and techniques designed to meet the challenge raised by increasing demands for electric power in rural areas.

Another interesting feature of the conference will take place on the afternoon of October 30, when conferees will make an inspection tour of nearby farm equipment manufacturing and industrial plants.

Additional Conference Papers Are Now Available

The following is the list of conference papers presented at the 1957 Summer General Meeting, Montreal, Que., Canada, June 24-28, which were not numbered at the time of the meeting. They have now been numbered and are available to members for 40¢ and to nonmembers for 80¢. Send order and remittance to: AIEE Order Department, 33 West 39 St., New York 18, N. Y.

CP57-877 The Application of Information Retrieval Systems to Military Logistics. *A. J. Allott*
876 Patent Searching by Punched Card Techniques. *D. D. Andrews*
863 A Photographic System for Data Retrieval and Presentation. *H. R. Ball*
872 Research in Canada for the Power Industry. *B. G. Ballard*
858 Improved Cable Insulating Oils. *S. C. Bartlett, J. E. Morrow, E. S. Ross*
869 Economic Implications of Automation. *J. J. Brown*
838 Coded Binary Counters for High-Speed Operation. *A. W. Carlson*
830 Telex—A New Telegraph Service for Canada. *C. J. Colombo*
852 The Stability of Electrical Insulation on Control Cable. *G. C. English, R. H. Brown, R. R. Cope*
875 St. Lawrence River High Voltage Submarine Cable Crossing. *D. M. Farnham, S. Cunha, G. B. Shanklin H. D. Short*
819 The Effects of Nuclear Radiation on Electronic Transformers and Transformer Materials in High Ambient Temperatures. *J. C. Fraser*
889 An Automatic A-C Network Analyzer Load Control Unit. *J. J. Gravel*
826 Progress Report on the Thermal Evaluation of Varnishes. *P. L. Hedrick*
CP57-834 Canadian Development in Defibrillation. *R. O. Heimbecker, W. J. Bigelow, G. Trusler*
892 New England Electric System's Experience with Below Ground Corrosion of Metals. *A. E. Hill*
881 Adjustable Voltage Traveling Bucket Cranes. *E. A. Horsley*
850 Engineering and Economical Problems of Telex Service. *Albert Jipp*
820 Hazards in Reactor Operation. *R. M. Johnston, D. C. King*
813 New Automatic Frequency Control System Suitable for Single Sideband Reception and FM Transmission. *L. R. Kahn*
878 Mechanized Dictionary for Language Translation. *Gilbert King*
818 Problems Associated with the Radiation Testing of Transformers in High Ambient Temperatures. *W. R. Langdon*
890 Establishing and Equipping the Hagerstown Educational Television Project. *L. L. Lewis*
883 Selecting Criteria for Transient Stability in Power System Planning. *B. L. Lloyd, C. A. DeSalvo*
882 An Integrated Analog-Digital Technique for Investigation of Dynamic Systems. *H. G. Lustig*
844 Electroplating Power Supply Design Considerations. *J. E. Main*
822 Description and Maintenance Procedures of Electrical and Air-Conditioning Equipment on Canadian Pacific Railway Company Stainless Steel Passenger Car Equipment. *A. E. McGruer*
859 Canadian Progress in Telephone Communication. *C. H. McGuire*
887 Insulation Evaluation for Medium Size Machines Using Form-Wound Motorettes. *G. L. Moses, R. D. Wolford, J. C. Bates*
823 Rehabilitation of Diesel-Electric Locomotive Electrical Equipment. *T. H. Murphy, R. L. Bogardus*
893 Steps for Reducing Underground Corrosion on Multigrounded Distribution Lines. *J. E. O'Brien, O. W. Zastrow*
862 Status Report on the Rapid Selector. *Philip Ordung, Thomas Bagg*
886 On the Order of the Differential Equation Describing an R-L-C Network. *J. Otterman*
860 Survey of Information Retrieval Tools Now Available. *Jack Rabinow*
894 History of Below Ground Corrosion of Steel Tower Footings on the Virginia Electric and Power Co. System. *J. A. Rawls*
891 Combatting Corrosion of Tower Footings, Anchors, and Grounding Systems. *C. H. Schofer*
815 Measurements of Radiation Doses by Absorption and Luminescence Changes in Solids. *J. H. Schulman*
873 Research Projects of the Electric Utility Industry. *H. P. Seelye*
865 Dielectric Strength of Cable Insulations. *A. H. Shepard, P. H. Ware*
855 Combined Analog-Digital Simulation of Sampled Data Systems. *H. K. Skramstad*
814 Conclusion. *J. Stair, Jr.*
816 Naval Research Reactor and Nuclear Research Program. *E. N. Stirewalt*
812 Simultaneous Transmission of Television and Telephone Multiplex Over a Single Microwave Channel on the Trans-Canada TD-2 System. *U. C. P. Strahlendorf, A. J. Wade, H. E. Curtis*
843 Applications of Semiconductor Rectifiers in Electrochemical Industry. *R. P. Stratford*
833 A-C Commutator Motors and Their Application in the Textile Industry. *C. T. Sym-Smith*
821 Medical Aspects of Radiation Hazard Control in a Power Reactor Installation. *R. M. Taylor*
866 Aerial Cable Installation Practice and Service Experience. *W. A. Thue*
884 Higher Retentions for Longer Pole Life. *H. M. Walton, Dr. C. W. Leach, Albert Hess*
857 Acceptance Tests and First Applications of a Combined Analog-Digital Simulation System. *G. West*
CP57-864 Recurrence Relations in the Solution of a Certain Class of Nonlinear Systems. *A. A. Wolf*
817 The Control System of the Naval Research Reactor. *M. P. Young, G. F. Wall*
895 Prevention of Below Ground Corrosion of Transmission Tower Structures. *E. J. Higgins, E. L. Zobel*
856 Simplified Two-Channel Data Link for Real-Time Combined Analog-Digital Simulation. *J. L. Greenstein*

Eastern Joint Computer Conference and Exhibit Extended

The wealth of fresh technical material to be presented has resulted in a decision to extend the 1957 Eastern Joint Computer Conference by an extra half-day according to announcement by Dr. S. N. Alexander, chairman of the conference.

The 1957 Conference, now scheduled for December 9-13, will take place at the Sheraton Park Hotel in Washington, D. C.

Dr. Alexander, chief of the Data Processing Systems Division, National Bureau of Standards, said that this year's conference theme—"Computers with Deadlines to Meet"—has aroused unusual interest. There will now be nine very full technical sessions, beginning early Monday morning and running through Friday at 1:00 p.m. The session topics range from "Industrial Control Computers and Instrumentation" to "On-Line Business Systems." In each case, the focus will be on the problems which arise in the design and application of computers which are required to perform their job within a specified time cycle. The role of simulations in analyzing the system problem will receive special attention.

This will be the seventh Eastern Joint Computer Conference to be sponsored by the AIEE, Institute of Radio Engineers (IRE), and Association for Computing Machinery (ACM). Also participating in this year's conference will be the National Simulation Council.

The basic purpose of the annual joint conferences is to promote the exchange of information on electronic computing equipment between designers, producers, users, and other interested groups. Since the first conference in Philadelphia, Pa., in 1951, the Eastern and Western Conferences have served both to stimulate, and through published Conference Proceedings, to record the rapid growth of interest and progress in the computer field. Beginning in 1951 with a general review of electronic digital computers, the conferences have successively focused on input and output equipment, information processing systems, small digital computers in business and industrial systems, and in 1956, on "New Developments."

Dr. H. H. Goode, professor of electrical engineering, University of Michigan, is chairman of the Program Committee. Assisting Dr. Goode on the Program Committee are: Arnold Cohen, Sperry Rand Corporation; Richard Sprague, Teleregister Corporation; Cal Johnson, Bendix Aviation Company; I. L. Auerbach, Burroughs Corporation; Jerry Haddad, International Business Machines Corporation; N. R. Scott, University of Michigan; and Dr. R. M. Howe, University of Michigan.

In addition to the technical sessions, there will be a large exhibit area devoted to displays of complete data processing and computing systems as well as of computer components and subassemblies. Sufficient space has already been engaged to insure a highly informative exhibit. All exhibits will be open to the public without charge.

A program announcement, complete with descriptions of session topics and individual papers, as well as advance registration and hotel reservation forms, was mailed during September to the following: ACM—all members; AIEE—Communications Division, Science and Electronics Divisions; IRE—Professional Group on Electronic Computers; National Simulation Council—all members.

Others who wish to have their names placed on the program mailing list should write to: R. T. Burroughs, Registration Chairman, 1957 EJCC, International Business Machines Corporation, 1220 19th Street, N. W., Washington, D. C. It is not necessary to belong to one of the sponsoring societies to attend the conference. Nonmembers are cordially invited.

Fees for registration are as follows: Advance registration—$4; Registration after November 25 (by mail or at conference) —$5.

"Our Year of Challenge"

The following is a message to the Cleveland Section of the AIEE from K. L. Wheeler, chairman of the Section.

"Last year the Cleveland Section celebrated its 50th Anniversary. Our first 50 years were years of growth and accomplishments; years for which we may all be proud. The 51st year is a year of challenge. A challenge to start on a new 50-year period which will outdo the first one. This year we must embark on a program of growth—growth in service to our members and to our communities; growth in service to our student branches; growth in our membership and growth in our members participation in our activities. Each member has a challenge to participate in this growth, to help it. The Cleveland Section of AIEE truly transcends geographical boundaries. We extend from Sandusky to the Pennsylvania line. Few organizations have such an outstanding opportunity to contribute to the future of northeast Ohio. If each member will accept this challenge and participate in the activities and the growth of the Cleveland Section, we can become one of the greatest participants of the bright future of the area we serve."

Lamme Medal Nominations Must Be Submitted By December 1

Members of the Institute again are reminded that they have an opportunity to submit nominations for the 1957 Lamme Medal. All nominations must be received not later than December 1, 1957.

Details regarding qualifications for the award were published in the August 1957 issue of *Electrical Engineering*, page 703.

U.S. Delegation Returns from IEC Meeting in Moscow

"Russian advances in electrotechnology and hydroelectric power represent surprising accomplishments," R. C. Sogge of General Electric Company, said recently. Mr. Sogge is leader of the 24-man U. S. delegation which attended an 11-day meeting in Moscow, U.S.S.R., of the International Electrotechnical Commission (IEC). He made his comments at a press conference held in the offices of the American Standards Association (ASA).

Mr. Sogge is president of the U. S. National Committee of the IEC, which is an arm of the ASA.

Delegates from 27 countries, totaling more than 500, attended the annual meeting of the IEC. During the July 2-12 Moscow meetings, 16 technical committees were in session.

Mr. Sogge said that the Soviets are planning a 1,000 mile direct-current transmission line between Moscow and power sources in Siberia. In addition, 400-kv power circuits are in operation, he said. United States delegates were told that the U.S.S.R. had turbogenerators rated at 150,000 kva in operation and is building them with 200,000 kva.

It was noticeable that some of the equipment in Soviet plants that were visited was much older than ours, but appeared to be in good running condition. Accident prevention and plant housekeeping were not as advanced as in United States industry, Mr. Sogge reported as being the concensus of the United States delegation.

Reports from the central committee of the IEC, which has headquarters in Geneva, Switzerland, indicate that 16 draft international standards have been received. "Numerous proposals were made by various countries which no doubt will go into international standards," Mr. Sogge said.

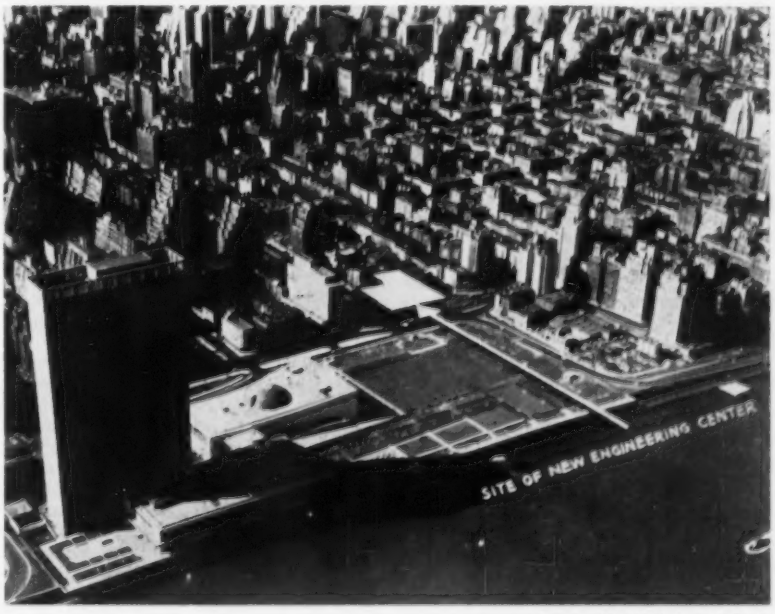
These will be considered by technical committees at future IEC meetings.

Other observations of industrial practices in the U.S.S.R. were made by various members of the United States delegation who saw large electrical apparatus plants, transformer works, automobile factories, and radio tube plants. Technical visits were made to plants in Moscow, Leningrad, and Zaporozhye. While at Leningrad, the Americans toured the Direct-Current Research Institute. Zaporozhye is the site of the pre-war Dnepropetrovsk installation

AIEE Members Contribute to Symposium Held in India

More than 60 engineers from all over India attended a three-day Symposium on Electric Power Transmission and Distribution held at Sindri in May 1957. The symposium was organized by the Bihar Institute of Technology under the guidance of its director, D. L. Deshpande, and

United Engineering Center



Courtesy New York Port Authority

THE NEW UNITED ENGINEERING CENTER is to be erected between 47th and 48th Sts. on United Nations Plaza, New York, N. Y. Col. C. E. Davies, building co-ordinator for the new Center, sailed, in August, for Europe where he will invite representatives of 13 Western European engineering societies to share facilities in the new Center.

San Francisco Section Officers

GAVEL CHANGES HANDS as AIEE San Francisco Section inaugurates 1957-58 officers. W. G. Collins, Pacific Telephone & Telegraph Co. (second from right), passes chairman's office to Prof C. F. Dalziel, University of California (second from left), as R. H. Miller, Pacific Gas & Electric Co., incoming secretary-treasurer (left), and M. G. Lewis, Bechtel Corp. (right), new vice-chairman, look on.

Prof. R. W. Atkinson (F '28), guest professor of electrical engineering.

During the symposium, a series of lectures were delivered by Dr. M. G. Malti (M '45), guest professor of electrical engineering at the University of Roorkee, on "Symmetrical Components."

The proceedings of the symposium were published in the June 1957 issue of *Indian Construction News*.

COMMITTEE ACTIVITIES

EDITOR'S NOTE: *This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.*

Communication Division

Telegraph Systems Committee (F. W. Smith, *Chairman;* V. N. Vaughn, Jr., *Vice-Chairman;* W. G. Vieth, *Secretary*). This Committee and the Data Communications Committee jointly sponsored a technical session at the Summer General Meeting in Montreal. Papers presented at the session covered loading coils for ocean cables, error detection in telegraph codes, a data transmission system, and an automatic teletypewriter exchange system.

The Committee plans to hold future joint technical sessions with the new Data Communications Committee, in addition to its regular independent sessions, because of the overlapping interest of the two committees in many problems associated with integrated data processing and data transmission.

The Printing Telegraph Subcommittee continued its investigation of acceptable tolerances for receiving margins of printing telegraph apparatus and acceptable limits for the distortion permissible in signals generated by telegraph apparatus.

Power Division

Relays Committee (W. K. Sonnemann, *Chairman;* R. A. Larner, *Vice-Chairman;* J. L. Blackburn, *Secretary*). The Relays Committee makes use of 12 active subcommittees. These subcommittees meet, as required, twice a year on the day before the Spring and Fall Meetings of the main Committee.

The Bibliography of Relay Literature Subcommittee submitted Transactions Paper 57-72 at the Winter General Meeting, January 1957, which brings the bibliography up to date through the years 1953-54.

The Relay Standards Subcommittee has submitted a conference paper type of interim report on Revisions to Relay Standards, Paper 57-71.

During the past year, this Subcommittee has made substantial progress in updating the American Standard for Relays Associated with Electric Power Apparatus *C37.1*-1950. They have revised or created new definitions for 58 terms. They have reached agreement that the present format of this standard is inadequate for the present expanding technology. They have been instrumental in suggesting an agenda for the International Electrotechnical Commission's Relay Standardization Project.

In spite of these accomplishments, there is a feeling among the committee members that the rapid strides being made in the field in relay technology are creating new terminology and nomenclature at a faster rate than old problems are being settled. Plans to offer a revision to AIEE Standard *C37.1*, this coming year have been dropped and a dissemination of AIEE Conference Paper 57-71 "Interim Report on Revisions to Relay Standards" is now contemplated. By properly publicizing this conference paper, it is hoped that the value of releasing a new standard will be sufficiently met to permit a delay of approximately one more year in issuing a revision of the present 1950 edition of this relaying standard. This delay will permit preparing a more complete and useful standard.

Other subcommittees continue to be active, and as their work is accomplished, additional reports will be issued.

AIEE FELLOWS ELECTED

Board of Directors Meeting, June 28, 1957

Emanuel Leonard Brancato (AM '39, M '45), electrical engineer, head, Insulation Section, Naval Research Laboratory, Washington, D. C., has been transferred to the grade of Fellow in the AIEE ". . . for basic research contributions in the field of electric insulation." Mr. Brancato was born in New York, N. Y., November 3, 1914. He received the B.A. degree in 1936 from Columbia College, the B.S. degree in 1937 from Columbia University, and the M.S. degree in E.E. in 1938 from Columbia University. After graduation, he joined the Boston Naval Shipyard in the Electrical Planning Division. In 1939, he became electrical engineer to the assistant head, Electrical Scientific Section, New York Naval Shipyard. In 1946, he was appointed head of the Power Systems Section, Electricity Division, Naval Research Laboratory, Washington, D. C. Since March 1954, he has been head of the Insulation Section, Solid-State Division, Naval Research Laboratory. Mr. Brancato is the author of several technical papers and has a patent on a ground detector to his credit. He is a member of the Electrochemical Society and the Scientific Research Society of America. He has been an active member of the Washington Section of the AIEE, serving as chairman of the Awards, Student Activities, and Membership committees. Mr. Brancato is a registered professional engineer in the State of New York. He has served on the AIEE Dielectrics Committee (1955-57).

Theodore Brownlee (AM '26, M '45), supervisor—test methods and facilities, General Electric Company, Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of equipment and techniques used in high voltage impulse testing." Mr. Brownlee was born in Cambridge, N. Y., May 17, 1903. He received the E.E. degree from Rensselaer Polytechnic Institute in 1924. From 1924 to 1948, he was development engineer, lightning arrester, cutout and capacitor engineering, General Electric Company. During this period, Mr. Brownlee was in active charge of the impulse generator and cathode-ray oscillograph laboratory used in the development of lightning arresters and other protective equipment. In 1948, he was transferred to the High Voltage Laboratory where he continued his work of improving testing equipment and techniques. In 1952, he was appointed supervising engineer, instrumentation and equipment, High Voltage Laboratory, and in 1953 was made supervisor, laboratory utilities. In 1954, he assumed his present position as supervisor—test methods and facilities. Mr. Brownlee has made a number of contributions to technical literature, including a paper on nonlinear resistors entitled "The Calculation of Circuits Containing Thyrite." Mr. Brownlee is a registered professional engineer in the State of Massachusetts and is a member of the National Society of Professional Engineers.

John Lucas Cantwell (AM '36, M '45), standards engineer, distribution transformer engineering department, General Electric Company, Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to functional testing and the evaluation of transformers and transformer insulating materials." Mr. Cantwell was born in Wilmington, N. C., September 3, 1906. He received the B.S. degree in E.E. from the University of North Carolina in 1927 and the M.S. degree in E.E. from Massachusetts Institute of Technology in 1929. Mr. Cantwell has been with General Electric since 1927 when he joined the company as a test engineer. He assumed his present position as standards engineer, distribution transformer engineering department, in July 1956. Mr. Cantwell has served on several committees of the American Standards Association and as a member of the Joint Committee on Standards for Distribution Transformers of the Edison Electric Institute and the National Electric Manufacturers Association. He is a past chairman of the AIEE Pittsfield Section and received the AIEE Best Paper Award in that Section for 1936. He was elected to Phi Beta Kappa in 1926. Mr. Cantwell is a registered professional engineer in the State of Massachusetts. He has served on the following AIEE Committees: Transformers (1947-57) and Dielectrics (1955-57).

James Cameron Clark (AM '09, M '21, Member for Life), professor of electrical engineering, University of Arizona, Tucson, Ariz., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions in the field of electrical engineering and education." Prof. Clark was born in Ossian, Iowa, July 28, 1882. After graduating from Iowa State College in 1907 with the B.S. degree in E.E. he went to the Westinghouse Electric Corporation as an engineering apprentice. In 1909, he joined the faculty of the Case School (now Case Institute of Technology). After two years at Case, he spent a year at Harvard University, receiving the M.E.E. degree in 1912. He then returned to teaching as his career, interrupting it occasionally for periods in the service of electrical manufacturers as a specialist in high voltage engineering. In recognition of his achievements in this field, Iowa State College conferred upon him in 1917 the professional E.E. degree. As a teacher of electrical engineering, Prof. Clark spent 12 years at Stanford University, and 1 year at Iowa State. He served for 27 years as head of the department of electrical engineering at the University of Arizona. Prof. Clark is a member of the American Society for Engineering Education, American Association of University Professors, Tau Beta Pi, and Eta Kappa Nu. He is the author of numerous technical papers and articles. Prof. Clark has served on the following AIEE Committees: Electrophysics (1919-24), Meetings and Papers (1920-23), Education (1936-37), and Student Branches (1951-52).

Joseph Herbert Cox (AM '24, M '45), engineering manager, Sunnyvale Plant, Westinghouse Electric Corporation, Sunnyvale, Calif., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to lightning protection through study of lightning phenomena, and to the development of mercury arc rectifiers." Mr. Cox was born in Newman Grove, Nebr., December 18, 1893. He received the B.S. degree in E.E. in 1923 from Massachusetts Institute of Technology where he was elected to Tau Beta Pi. After graduation, he joined the Westinghouse Electric and Manufacturing Company. In 1924, he was assigned to Dr. Fortescue's group, studying lightning phenomena and surges on transmission lines. In 1929, he was transferred to the Manufacturing Section, developing mercury arc rectifiers, and one year later became manager of the section. When Dr. Slepian discovered the ignitron principle, Mr. Cox was chiefly responsible for converting the idea to a commercial device. In 1945, he was transferred to the Pacific Coast Plant at Emeryville as engineering manager. In 1947, he went to the Sunnyvale Plant as manager of quality control, later becoming engineering manager. Mr. Cox holds 24 patents and is the author of numerous technical articles. He was active in the organization of the Bay Area Section of the American Society for Quality Control and has served as its chairman. He is a registered professional engineer in the State of Pennsylvania. Mr. Cox has served on the following AIEE Committees: Electrical Machinery (1938-43), Electronics (1942-45), and Electronic Power Converters (1947-50).

Waldo Edward Enns (AM '37, M '44), chief system engineer, Portland General Electric Company, Portland, Oreg., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of a power utility system and the invention of a simplified network analyzer." Mr. Enns was born in Trenton, Mo., November 8, 1901. He received the B.S. degree in E.E. from the University of California in 1924. From 1925 to 1929, Mr. Enns was employed by the Southern California Edison Company. He then held positions with Electrical Research Products, Inc., and the Water and Power Department of the City of Los Angeles. He joined the Portland General Electric Company in 1936 as electrical draftsman. He was made assistant electrical engineer in 1939, electrical engineer in 1943, assistant chief engineer in 1947, and chief system engineer in March 1957. Mr. Enns won the AIEE District No. 9 First Prize Award in 1941 for one of the several technical papers he has written. A member of Eta Kappa Nu, he is past chairman of the AIEE Portland Section and served as

E. L. Brancato

Theodore Brownlee

J. L. Cantwell

Courtesy Reginald Russell

J. C. Clark

J. H. Cox

Photo-Art Commercial Studios

W. E. Enns

Courtesy Elliott and Fry, Ltd.

R. M. Fairfield

J. G. Ferguson

W. R. Harris

Photography by E. F. Hill

A. P. Hill

technical program chairman for the 1951 AIEE Pacific General Meeting in Portland. He has served as chairman of the Electrical Equipment Committee of the Engineering and Operation Section of the Northwest Electric Light and Power Association and as a member of the Executive Committee of that section. Mr. Enns has served on the following AIEE Committees: Sections (1944-47) and Switchgear (1947-54).

Ronald McLeod Fairfield (M '46), director of production and engineering, British Insulated Callender's Cables, Ltd., London, England, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development, improvement and manufacture of high voltage electric power cables." Mr. Fairfield was born in Newcastle-on-Tyne, England, on May 25, 1911. He received the B.S. degree in engineering from the University of London in 1934. Before that year, he had been associated with the Newport Corporation as a trainee, and with Callender's Cable & Construction Co., Ltd., as a trainee and as research engineer. From 1934 to 1937, he was with Philips Ltd., Eindhoven, Holland, and Mullard Radio Valve Co. In 1937, he became technical manager, Leigh Works, Callender's Cable & Construction Co. and in 1942, the responsibility for two other factories at Erith, Kent, and Denton, Lancashire, were added. He became chief engineer, designs and processes, for British Insulated Callender's Cables, Ltd., in 1945. From 1948 to 1952, he was director and general manager St. Helens Cable & Rubber Co., Ltd., Slough, Buckinghamshire, and from 1952 to 1954, he was director and general manager, W. T. Glover & Co., Ltd., Manchester. He also was director and general manager of British Insulated Callender's (Submarine Cables) Ltd., from its formation in 1953. In 1955, he assumed his present position as director of production and engineering, British Insulated Callender's Cables Ltd. Mr. Fairfield is a member of the Institution of Electrical Engineers, Institution of Mechanical Engineers, and a fellow of the Royal Society of Arts. He was a member of the Cable Maker's Technical Committee set up by the British Government during World War II to advise on all technical matters relating to electric cables.

John Gilbert Ferguson (AM '18, M '29, Member for Life), transmission measurement engineer, Bell Telephone Laboratories, Inc., Murray Hill, N. J., has been transferred to the grade of Fellow in the AIEE ". . . in recognition of his contributions in the fields of primary electrical measurements and electronic measuring techniques." Mr. Ferguson was born in Brewarrina, New South Wales, Australia, June 5, 1892. After receiving the B.S. degree in E.E. from the University of California in 1915, he spent a year as research assistant in physics at the University, receiving the M.S. degree in physics in 1916. He joined the engineering department of the Western Electric Company in 1916 and in 1922 was placed in charge of a group developing electrical measuring apparatus for use in the telephone industry. He was transferred to the Bell Telephone Laboratories when they were organized in 1925. During World War II, he was responsible for the development of a variety of communication and electronic equipment for the armed services. In 1949, he was appointed transmission measurement engineer. In this capacity, he has directed the development of measuring apparatus for the Bell Telephone Laboratories, the Western Electric Company, and the associated Bell Telephone Companies. Mr. Ferguson has made valuable contributions to the literature on measurements and standards and holds five U. S. patents. He is a member of Sigma Xi, Institute of Radio Engineers, American Association for the Advancement of Science, Montclair Society of Engineers, and the Green Mountain Club. He has served on the following AIEE Committees: Instruments and Measurements (1950-56), Feedback Control Systems (1951-56), Special Instruments and Auxiliary Apparatus (1956-57).

Walter Randolph Harris (AM '38, M '44), manager, industry engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the design and application of control systems for the precise regulation of speed, tension and position." Mr. Harris was born in Crockett, Va., June 3, 1915. He received the B.S. degree in E.E. from West Virginia University in 1937, and the M.S. degree in E.E. from the University of Pittsburgh in 1941. Mr. Harris joined Westinghouse in 1937 as paper mill application engineer. He became rolling mill application engineer in 1946 and manager of rolling mill application engineering in 1948. In 1953 he was appointed to his present position as manager, industry engineering department. Mr. Harris holds 19 patents and has written numerous technical papers and articles. He is a member of the Association of Iron and Steel Engineers, and is a registered professional engineer in the State of Pennsylvania. In 1956, he was made secretary-treasurer of the AIEE Pittsburgh Section. He has contributed to the advanced education of engineers by teaching a graduate level engineering course at the University of Pittsburgh. He also has been made a director of the Westinghouse Educational Center. Mr. Harris has served on the following AIEE Committees: Mining and Metal Industry (1947-56, chairman 1953-55); Award of Institute Prizes (1952-57); Industry Division (1953-55, 1956-57); and Publications (1955-57).

Arthur Paul Hill (AM '23, M '29), retired, has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of wire and radio communications, sound motion pictures and acoustical technology." Mr. Hill was born in Bradfield, Berkshire, England, on January 13, 1889. He attended Bloxham School, Oxford, from 1903 to 1906, as well as the British Institute of Electricity and Telegraphy from which he was graduated in 1909. From 1909 to 1918, he served in the British Naval Reserve as wireless officer and instructor with the Marconi Wireless Telegraph Company of Canada. He then served as instructor with the Dominion Telegraph Institute and Sprott-Shaw Institute. In 1922, he became transmission radio engineer in the plant department of the Southern California Telephone Company in Los Angeles, where he made major contributions, in the formative days, to radio communication, broadcasting and program facilities, and public address system design and application. From 1929 to 1936, he was recording engineer with the Western Electric subsidiary, Electrical Research Products, Inc. In this position he assisted in the Bell System's activities relating to the change from silent to talking motion pictures. A book entitled "Motion Picture Sound Engineering," D. Van Nostrand Co., 1938, contains material prepared by Mr. Hill for fundamental and advanced courses. In 1936, he became transmission engineer in the chief engineer's department of the South-

ern California Telephone Company (now the Pacific Telephone and Telegraph Co.), retiring in January 1954 at the age of 65. Mr. Hill is a member of the Academy of Motion Picture Arts and Sciences and an honorary members of Eta Kappa Nu. He has been an active member of the Los Angeles Section of AIEE, serving as a member of the Executive Committee; as secretary, 1931-32; vice-chairman, 1932-33; and as chairman of the Section, 1933-34. He has been a member of the following AIEE Committees: Sections (1934-36), and Communication (1941-44).

Arthur V. Loughren (M '56), vice-president in charge of research, Airborne Instruments Laboratories, Mineola, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for technical leadership in the electronic industry with major contributions toward standardization of color television." Mr. Loughren was born in Rensselaer, N. Y., September 15, 1902. He received the B.A. degree from Columbia College in 1923 and the E.E. degree from Columbia Engineering School in 1925. He was employed by the General Electric Company and the RCA Manufacturing Company before he joined the Hazeltine Electronics Corporation in 1936. He served as engineer in charge of television development until World War II. After this he was design supervisor responsible for work on various radar identification equipment for which he received a Naval Certificate of Commendation in 1947. He was made chief engineer in 1946. From 1949 to 1952, he served as vice-president in charge of research, conducting an active program in the development of color television. In 1952, he became director of research of Hazeltine Corporation and vice-president of Hazeltine Research, Inc. He was made vice-president of Hazeltine Corporation in 1954. He joined Airborne Instruments Laboratories in 1956. During his career, Mr. Loughren has received the following honors: David Sarnoff Medal of the Society of Motion Picture and Television Engineers (SMPTE), 1953; Plaque of Radio-Electronic-Television Manufacturers Association (RETMA) and the Institute of Radio Engineers (IRE), 1954; and the Morris Liebmann Memorial Prize of IRE. He served as president of the IRE for 1956. Mr. Loughren was active in both the first and second National Television System Committees. He is the author of numerous technical papers and holds over 25 U.S. patents. He is a fellow of the SMPTE and of the Radio Club of America.

Wayne J. Morrill (AM '25, M '35), president of Electric Motors & Specialties Company, Garrett, Ind., and president of Morrill Motors, Inc., Fort Wayne, Ind., has been transferred to the grade of Fellow in the AIEE ". . . for achievement in the design and manufacture of fractional horsepower motors." Mr. Morrill was born in Fort Wayne, Ind., February 22, 1901. He received the B.S. degree in E.E. from Purdue University in 1923. After graduation, he joined the General Electric Company on the Test Course. He then entered the fractional horsepower engineering department as a designing engineer. He was presented with the General Electric Coffin Award for developing the first commercially successful line of single-phase capacitor motors. In 1943, he formed the Electric Motors & Specialties Company in partnership with E. J. Schaefer for the purpose of designing and manufacturing special military equipment for the U. S. Signal Corps. In 1945, the partnership was dissolved and Mr. Morrill continued as president of the company. In 1944, he organized Morrill Motors, Inc., to build a highly special motor alternator for use in one of the first radar bomb sights. Mr. Morrill holds over 50 U. S. patents and is the author of several technical papers, including "The Revolving Field Theory of the Capacitor Motor." He is a member of Sigma Xi. Mr. Morrill has served on the following AIEE Committees: Electrical Machinery (1940-44), Management (1954-57), and Code of Principles of Professional Conduct (1954-56).

***Ralph Edgar Neidig** (AM '38, M '47), chief engineer, Metropolitan Edison Company, Reading, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to planned development and operating reliability of an electric power system." Mr. Neidig was born in Reading, Pa., November 30, 1904. He received the B.S. degree in E.E. from Tri-State College in 1924. He joined the Metropolitan Edison Company in 1925 as assistant relay engineer, becoming relay engineer in 1927, electrical engineer in 1941, operating superintendent of the Reading Division in 1947, assistant chief engineer in 1952, and chief engineer in 1953. In this last position, which he holds at the present time, he is responsible for all engineering projects of the company including system planning and general supervision of design of generating stations, substations, and distribution and transmission lines. Mr. Neidig is a registered professional engineer in the State of Pennsylvania. He has served on committees of the Pennsylvania Electric Association, Edison Electric Institute, and Middle Atlantic Utilities Radio Association. He is a past chairman of the AIEE Lehigh Valley Section and was vice-chairman of the 1954 Middle Eastern District Meeting of the Institute. Mr. Neidig has served on the following AIEE Committees: Carrier Current (1947-49), and Protective Devices (1951-55).

*Mr. Neidig's transfer to the grade of Fellow was effective August 1, 1957.

Edward J. Schaefer (AM '28, M '35), president, Franklin Electric Company, Bluffton, Ind., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the design and overload protection of small motors." Mr. Schaefer was born in Baltimore, Md., July 10, 1901. He received the B.S. degree in E.E. from Johns Hopkins University in 1923. He entered the Test Course of the General

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Courtesy Sanderson

A. V. Loughren

Clippinger, Town House

W. J. Morrill

Photo by Paul Bauer

R. E. Neidig

E. J. Schaefer

Van Dyke Studio, Inc.

S. R. Smith, Jr.

A. G. Steinmayer

S. C. Townsend

Electric Company, Schenectady, N. Y., in 1923 and was a member of the first class in the Advanced Course in Engineering. From 1928 to 1943, he was in the fractional horsepower engineering department of the company in Fort Wayne, Ind. During this period, he received the General Electric Coffin Award, the highest award of merit conferred by the company, for the development of built-in thermal overload protection for small motors. In 1943, he resigned from the General Electric Company and became a partner, with W. J. Morrill, of the Electric Motors & Specialties Company which engaged in the design and manufacture of special military equipment for the U. S. Signal Corps. In 1945, the partnership was dissolved and Mr. Schaefer founded the Franklin Electric Company in Bluffton, Ind. He is president of this company. Mr. Schaefer holds 30 U. S. Patents. He presented a paper on submersible motors at the AIEE Great Lakes District Meeting in Fort Wayne in 1956.

Sidney Robert Smith, Jr. (M '46), supervisor, lightning arrester and cutout advance development, General Electric Company, Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the development of protective devices for electric power distribution systems." Mr. Smith was born in Gainesville, Texas, January 2, 1906. He received a B.S. degree in general engineering from Georgia Institute of Technology in 1929. After graduation, he joined the General Electric Company in Schenectady, N. Y. In 1934, he transferred to Pittsfield, Mass., working in design and development engineering, distribution cutouts. He was made leader of the distribution cutout development group in 1947 and was appointed to his present position as supervisor, lightning arrester and distribution cutout development in 1954. Mr. Smith received a General Electric Managerial Award for the development of a meter which so reduced testing time as to permit statistical determination of variation in fuse line time current characteristics. This led to improvements in fuse link accuracy and thus, better continuity of service on electric utility distribution systems. Mr. Smith holds 40 U.S. patents and has had several technical articles published in *Distribution* Magazine. He is a registered professional engineer in Massachusetts and is a member of the Massachusetts Society of Professional Engineers.

Alwin G. Steinmayer (AM '19, M '36, Member for Life), vice-president of research and engineering, Line Material Industries, Division of McGraw-Edison Company, Milwaukee, Wis., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to equipment for power distribution systems particularly in the field of cutouts and fuses." Mr. Steinmayer was born in LaSalle, Ill., January 4, 1894. He received the B.S. degree in E.E. from the University of Illinois in 1916. During the early years of his career, he was associated with Triumph Electric Company and Electrical Engineers Equipment Company. He joined Line Material Company as chief engineer in 1923. In 1936, he was made vice-president of the company. During 1939, he became a director of the Line Material Company and retained this position until Line Material became a Division of the McGraw Electric Company in 1949, at which time he became vice-president of research and engineering. Mr. Steinmayer holds approximately 165 U. S. patents on various devices dealing primarily with the electrical distribution equipment business and street lighting. Mr. Steinmayer is a member of the Engineers' Society of Milwaukee and was selected "Engineer of the Month" for the March 1955 issue of *Milwaukee Engineering*. He is a member of the American Society for Testing Materials and for many years has been active in the standardization work of the National Electrical Manufacturers Association. He is a registered professional engineer in the State of Wisconsin. During World War II, he served on various Industry Advisory Committees of the War Production Board.

Stanley C. Townsend (M '47), manager, atomic power department, Pennsylvania Power & Light Company, Allentown, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to the production and transmission of electric power." Mr. Townsend was born in Philadelphia, Pa., July 31, 1898. After graduating from Lehigh University in 1920, he became a draftsman for the Pennsylvania Railroad Company. He joined the Pennsylvania Power & Light Company in 1924 as assistant engineer. He held various positions in the office of electrical engineer, the office of system planning engineer, the engineering department, and the engineering and construction department. In 1945, a company reorganization placed all electrical engineering under his supervision. In 1955, he was appointed manager of the atomic power department. Mr. Townsend is an active member of the AIEE Lehigh Valley Section of which he is immediate past chairman. He also has been very active in the Electrical Equipment Committee of the Edison Electric Institute, taking part in committee work and serving as chairman of the Apparatus and Design Subcommittee for the past two years. He is a member of the American Nuclear Society, Pennsylvania Society of Professional Engineers, National Society of Professional Engineers, and the Conference International des Grands Reseaux Electriques. A registered professional engineer in the State of Pennsylvania, Mr. Townsend is the author of several technical papers.

AIEE PERSONALITIES

Hendley Blackmon (M '32, F '49), engineering manager of association activities, Westinghouse Electric Corporation, has been appointed head of the AIEE Technical Operations Department for the administrative year 1957-58. Mr. Blackmon was graduated from the Georgia School of Technology in 1925 with the B.S. degree in E.E. After a year on the Westinghouse Graduate Student Course, he had assignments in the switchboard engineering department, general engineering department, and public relations department. In 1945, he joined McGraw-Hill Publishing Company, becoming managing editor of *Electrical World* before he returned to Westinghouse in 1949. In 1951, he was appointed to his present position. Mr. Blackmon has been active in a number of organizations including the American Standards Association, National Electrical Manufacturers Association, and American Society of Mechanical Engineers. He has served on several AIEE Committees including Safety (chairman 1951-53), Technical Program, Technical Operations, Planning and Co-ordination, and Board of Examiners, and as a member of the Administrative Department of the Institute.

J. L. Callahan (M '35, F '48), research administrator and assistant to the manager, Radio Research Laboratory, RCA Laboratories, Radio Corporation of America (RCA), Rocky Point, L. I., N. Y., has been named head of the AIEE Admission and Advancement Department for the 1957-58 administrative year. Mr. Callahan received his early engineering train-

Hendley Blackmon

J. L. Callahan

L. R. Gaty

ing in Army schools, and later took a postgraduate course at Sorbonne University, Paris, France. In 1920, he became associated with the engineering department of RCA in communication research, and in 1930, he was made research section head in charge of the Terminal Facilities Research Laboratory. From 1945 to April 1957, he was assistant to the director, Radio Research Laboratory. Mr. Callahan is a Fellow of the Radio Club of America and the Institute of Radio Engineers. He served on the AIEE Board of Directors, 1948-50, 1956-57, and has been a member of numerous AIEE Committees including Communication, (chairman 1947-48), Communication and Science Co-ordinating, Standards, Technical Program, Executive Committee, Edison Medal, Communication Division, Planning and Co-ordination, Board of Examiners, Joint AIEE-Institute of Radio Engineers Co-ordination Committee, General Electric Educational Fund Fellowship Committee, Student Branches, and Publication. He was vice-president of AIEE District No. 3, 1948-50.

L. R. Gaty (AM '39, F '50), vice-president, research and development, Philadelphia Electric Company, Philadelphia, Pa., has been named head of the AIEE Publications Department for the administrative year 1957-58. Mr. Gaty was graduated from Cornell University with the E.E. degree in 1924. Since that date, he has been employed in the electric utility business with the Philadelphia Electric Company and predecessor companies. His experience has been in various operating and engineering assignments, including that as manager of engineering from 1948 to 1956, at which time he was appointed vice-president, research and development. Mr. Gaty is a member of the American Society of Mechanical Engineers, The Engineers Club of Philadelphia, Franklin Institute, and American Society for Engineering Education. He has served on the following Institute Committees: Power Transmission and Distribution, Management (chairman 1955-57), Planning and Co-ordination, Research, and Technical Operations, and was a member of the Professional Development and Recognition Department.

R. A. Heising (AM '15, F '39), consulting engineer, Summit, N. J., has been named head of the AIEE Professional Development and Recognition Department for the administrative year 1957-58. Mr. Heising received the E.E. degree from the University of North Dakota in 1912. He also holds the M.S. degree in physics from the University of Wisconsin and an honorary D.Sc. degree from the University of North Dakota. He entered the employ of the Western Electric Company research department in 1914 and continued in that department in 1925 when the engineering department of the Western Electric Company was separated to form Bell Telephone Laboratories. In 1945, he transferred to the patent department of Bell Telephone Laboratories, retiring in 1953. He is now practicing as an independent consulting engineer. Mr. Heising holds over 130 U. S. patents. He is a Fellow of the American Physical Society, Institute of Radio Engineers (IRE), and the American Association for the Advancement of Science. Among the awards he has received are: Morris Liebman Memorial Prize and Founders Medal from IRE, Modern Pioneer Award from the National Association of Manufacturers, and Armstrong Medal from the Radio Club of America. He has served as member and chairman of the AIEE Board of Examiners and as a member of the Administration and Advancement Department.

W. B. Morton (AM '25, F '42), chief electrical engineer, Pennsylvania Power & Light Co., Allentown, Pa., has been appointed chairman of the AIEE Administration Department for the administrative year 1957-58. After early experience with the U.S. Navy, Mr. Morton became a designer for the Pacific Gas and Electric Co. In 1925, he joined the Alabama Power Company and in 1931 became associated with the Philadelphia Electric Co. During World War II, he served as a commander in the U.S. Navy. In 1945, he joined the Pennsylvania Power & Light Company, where he was named chief electrical engineer in 1957. Mr. Morton is a member of several technical organizations including the Edison Electric Institute, Institute of Radio Engineers, Illuminating Engineering Company, National Society of Professional Engineers, and American Society for Engineering Education. Mr. Morton served as a director of the AIEE, 1941-46, and as vice-president of District No. 2, 1953-55. He has been a member of many Institute committees, including Sections, Membership, Technical Program, Transfers, Land Transportation, Marine Transportation, Planning and Co-ordination, and Public Relations, and has just completed a two-year term as chairman of the Student Branches Committee. He also has served as a member of the Admission and Advancement and the Professional Recognition and Development Departments.

R. A. Lebowitz (AM '43), section head of the Research and Development Engineering Division, Polytechnic Research & Development Co., Inc. (PRD), Brooklyn, N. Y., has been appointed assistant to the manager of manufacturing.

J. R. M. Alger (AM '50), analytical design engineer, aircraft generator products engineering, General Electric Co., Erie, Pa., has been made manager, Advanced Technical Programs, Engineering Training and Education, General Electric Co., Schenectady, N. Y. Mr. Alger received the

J. Saltzberg & Associates

R. A. Heising

W. B. Morton

M.S. degree in E.E. from Massachusetts Institute of Technology (MIT) in 1950. He joined General Electric at Schenectady on the Test Program in September 1950. Mr. Alger was recently appointed to the AIEE Educational Publications Committee.

W. H. Martin (AM '14, F '30, Member for Life), director of research and development, Department of the Army, was awarded the honorary degree of doctor of science by The Johns Hopkins University on June 11, 1957. Mr. Martin, appointed to his present position in September 1955, had been Deputy Assistant Secretary of Defense for applications engineering since January 1954. Prior to that time, he had served as vice-president of the Bell Telephone Laboratories.

J. F. Fairman (AM '20, F '35, HM '55), vice-president, Consolidated Edison Company of New York, has been elected a director of the National Association of Manufacturers (NAM). Mr. Fairman, who is a past president of the AIEE (1949-50), also was named chairman of the NAM Nuclear Energy Committee which is made up of 175 leaders of the atomic industry. Mr. Fairman has been a member of numerous general and technical committees of the Institute. He was vice-president of District No. 3, 1944-46, and served on the AIEE Board of Directors, 1944-52.

Cledo Brunetti (F '48), managing director, engineering, research, and development, Mechanical Division, General Mills, Inc., Minneapolis, Minn., has accepted an executive position with the Food Machinery and Chemical Corporation in San Jose, Calif. Dr. Brunetti has served on the following AIEE Committees: Research (1949-55), and Electronics (1951-54).

E. W. Kenefake (AM '43, M '48), microwave sales manager for the communication products department, General Electric Company, Syracuse, N. Y., has been named sales manager for power line carrier equipment. Mr. Kenefake has been a member of several AIEE technical committees and served as chairman of the Special Communication Applications Committee (1949-51).

L. S. Billman (AM '36), design engineer, Cornell-Dubilier Electric Corporation, South Plainfield, N. J., has been appointed chief engineer of the Power Factor Capacitor Division.

N. H. Mageoch (AM '44), staff assistant to the general manager of the Eclipse Machine Division of Bendix Aviation Corporation, Elmira, N. Y., has been promoted to assistant general manager.

D. A. White (AM '46), Birmingham district manager, The Okonite Company, and **J. G. Wicks** (AM '48), Philadelphia district manager, have been appointed regional sales managers of the company. Mr. White will supervise the activities of the Birmingham, New Orleans, and Dallas districts.

The Philadelphia, Boston, Cincinnati, Syracuse, Detroit, Cleveland, and Pittsburgh offices will report to Mr. Wicks.

OBITUARIES

William G. Briggs (M '50), application engineer, Milwaukee District Office, I-T-E Circuit Breaker Company, died recently. Mr. Briggs was born in Minneapolis, Minn., and graduated from the University of Minnesota College of Engineering as an electrical engineer. After serving in World War I, he became associated with the Commonwealth and Southern Association in Jackson, Mich. In 1935, he joined the I-T-E Circuit Breaker Company and served as application engineer in the Chicago, Ill., District Office for the next 20 years. In 1956, he moved to Milwaukee, Wis., in the same capacity in the newly established Milwaukee District Office. Mr. Briggs was a registered professional engineer.

Alfred Herz (AM '08, M '16, F '21, Member for Life), retired engineer of tests for the Public Service Company of Northern Illinois, died recently. Mr. Herz was born in Darmstadt, Germany, in 1876 and moved to London, England at an early age. His formal education was received in England and Germany, and in New York, N. Y. His career in the electrical industry in Chicago, Ill., started in 1906 with the North Shore Electric Company, a predecessor of the Public Service Company. He served in the electrical testing field until his retirement in 1942. In the early days, he pioneered in the parallel operation of small plants through transmission lines and in inductive co-ordination between power and communication systems. Many of his suggestions were adopted by manufacturers to improve the performance of equipment. Mr. Herz was the inventor of some 40 patented devices, many of which are serving the industry today. A number of his patents were in the photographic field. He was an active member of the Chicago Section of the AIEE. Mr. Herz was also a member of the Western Society of Engineers and the Physicist's Club in Chicago.

Robert Mac Donald (AM '28), filter planning engineer, Western Electric Company, died recently. Mr. Mac Donald was born in Glasgow, Scotland, on May 11, 1902. He received his undergraduate training leading to the degree of electrical engineer at the Royal Technical College at Glasgow and the London Institute of Technology. After working at the English Electric Company in Stafford and the Ericsson Telephone Company in Nottingham, England, he came to the United States in 1937. Graduate work was done in industrial engineering at Rutgers University. After being associated with the Weston Instrument Company as a tool designer, he joined the Western Electric Company as an equipment engineer. He then became product engineer on communication networks and filters. During the past five years, he was engaged in engineering problems associated with the manufacture and development of quartz oscillator and resonator crystal units.

Joseph Maximus Pestarini (F '50), inventor and educator, died recently in Rome, Italy. During his career, Dr. Pestarini had been a consulting engineer for several electrical firms. His most widely known invention was the metadyne for which he received the Montesano Award and Gold Metal of Leonardo da Vinci from the Italian Government. During 1956, he had served as visiting professor of electrical engineering at the University of Minnesota.

G. P. Williamson (M '47), consultant, Crocker-Wheeler Division of Elliott Company, died recently. Mr. Williamson entered the employ of the Crocker-Wheeler Company upon graduation from Columbia University in 1907 and was active until about two years ago when he assumed the status of consultant. He was an outstanding authority in the field of d-c motor and generator design, particularly as applicable to the metal-working industry.

CORRECTION: In column 1 of page 518 of the June 1957 issue of *Electrical Engineering*, the company affiliation of L. R. Kahn was incorrectly listed. It should read: L. R. Kahn, Kahn Research Laboratories.

MEMBERSHIP

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member have been received from the following candidates, and any member objecting to election should so notify the Secretary before October 25, 1957, or December 25, 1957, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Bennett, G. E., manager, insulating oils dept., Dussek Bros. & Co., Ltd., Crayford, Kent, England

Berger, E. G., Air Force adviser, U. S. Air Force, Municipal Airport, Salt Lake City, Utah

Branch, B. S., Tennessee transmission & protection engineer, Southern Bell Tel. & Tel. Co., Nashville, Tenn.

D'Mello, E. M., superintendent of transformer designs, M/S National Electrical Industries, Ltd., Bombay, India

Emmert, J. L., head-engineering dept., College of Steubenville, Steubenville, Ohio

Frankenberg, R. H., electrical engineer, Federal Power Commission, Fort Worth, Texas

Harris, M., partner, Cotton & Harris, Washington, D.C.

Harrison, R. E., assistant electrical engineer, Montreal Engineering Co., Ltd., Montreal, Que., Canada

Heinrich, O. X., instrumentation engineer, James G. Biddle Co., Philadelphia, Pa.

McCammon, D. K., electrical engineer, General Electric Co., range & water heater dept., Louisville, Ky.

McGeorge, R. P., service engineer, Westinghouse Electric Corp., Philadelphia, Pa.

Mussen, G. A., research engineer, electrical conductor engineering dept., Aluminum Laboratories, Ltd., Kingston, Ont., Canada

Spaulding, C. P., vice-president & general manager, G. M. Giannini & Co., Inc., Datex Division, Monrovia, Calif.

Stacy, R. M., service-test liaison engineer, Fairbanks, Morse & Co., locomotive engineering dept., Beloit, Wis.

Strawbridge, R. B., Sr., electrical engineer, GS-9, USN, U. S. Naval Training Center, Bainbridge, Md.

Vore, M. P., engineering section manager, Westinghouse Electric Corp., Baltimore, Md.

Yerdon, G. W., engineer specialist, North American Aviation, Downey, Calif.

17 to grade of Member

ELECTRICAL ENGINEERING EDUCATION

AIEE in University of Cincinnati

THE CHARTER for an AIEE Student Branch was presented to the University of Cincinnati on April 10, 1908. Counselor for the Branch, which is composed of approximately 100 students, is W. H. Middendorf.

The academic school year 1956-57 marked the 50th anniversary of the co-operative plan of education in the United States. This plan was originated at the University of Cincinnati in 1906 by the late Dean Herman Schneider. The three units using the co-operative plan at the University are: the College of Engineering, College of Business Administration, and College of Applied Arts. The College of Engineering offers co-operative courses in aeronautical, chemical, civil, electrical, mechanical, and metallurgical engineering. The Herman Schneider Memorial Quadrangle *(right)* honors the originator of the co-operative plan of education.

"Is Five Dollars Too Much?"

J. W. RITTENHOUSE
MEMBER AIEE

MANY TIMES this Fall the question will be asked, "What do I get for my five dollars?" If you are a student of electrical engineering, you will probably ask this question at least once during the coming semester.

If you pose this question to the AIEE member who is endeavoring to recruit you as a Student Member of the Institute, he will probably enumerate these tangible rewards of membership: the magazine *Electrical Engineering*, a reduced subscription rate to one of several bimonthly publications, a student membership badge, and so on.

All this may not seem to be worth $5* when measured on the scale of values which has significance to you as a student. But viewed from the vantage point of the collective experience of thousands of professional engineers, the $5 is indeed a paltry sum. For life has proved that the greatest asset of membership is the protection and enhancement of the professional status of engineers to a position consistent with his contributions to a society becoming more and more dependent on its engineers and scientists.

Role of Public Opinion

The simple fact is that there are powerful currents running through public opinion that tend to deprecate the role of the engineer and the engineering profession in general. The movement toward true professional status is impeded by cobblestones of immense dimensions. Depreciatory allusions that result from widespread appropriation of the title "engineer" by groups of skilled workers, so that its meaning has been diluted, are one of the main impediments. Newspapers carry many stories of labor strife involving groups of workers who carry the title of "engineer." They range from radio station technicians to drivers of gravel trucks. This unfavorable publicity has created in the public mind a less than respectful attitude toward "engineers" and their activities. In addition, there are the individual skilled tradesmen, the tinsmith who advertises himself as a "heating and ventilating engineer"; the case of the scrub-brush salesman who terms himself a "floor engineer"; the case of the janitor who seeks prestige among his friends through appropriation of the title "combustion engineer"; in fact, cases of groups or individuals who unjustifiably appropriate unto themselves the title "engineer" in their efforts to acquire public esteem are present everywhere.

A complete study of the psychology of public opinion which causes it to look upon a specialized group as professionals or subprofessionals is an exceedingly complex one. An elementary analysis of fundamentals, however, reveals that in the evaluation of the professional status of a group, society will be impressed invariably by the two characteristics: technical proficiency, and cultural fullness.

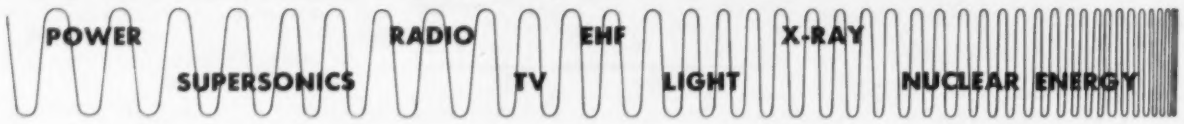
AIEE Aims and Activities

In the light of these threats to the engineer's professional status, it seems appropriate to pause briefly and look from an expanded point of view at the AIEE. It solicits not your $5 membership fee but your active participation in the affairs of

J. W. Rittenhouse is chairman of the Student Branches Committee and is technical director with the Hi-Voltage Equipment Co., Cleveland, Ohio.

*Bylaws of American Institute of Electrical Engineers specify that initial dues payable with application for enrollment shall be $5 if the application is filed at Institute Headquarters between February 1 and July 31 inclusive and $2.50 if the application is filed at any other time.

Electrical Engineering Education



an Institute which is dedicated to the maintenance of the high and noble standards which must be the guiding principles of true professional activities.

It is most significant that the AIEE has been working for over a half-century for the establishment and maintenance of a high level of technical proficiency among electrical engineers. Since its founding in 1884, it has conducted an extensive program designed specifically to encourage its members in the extension of all phases of the electrical engineering art.

Through its program to stimulate the publication of technological information, it has expanded from a society which in 1884 held one meeting at which one technical paper was presented to a society which, in the 1953-54 year, saw the presentation of 4,350 technical papers in approximately 2,500 meetings.

The intense interest of AIEE in the technical competence of its members, and of engineers in general, was evidenced in 1932 when its representatives met with representatives of American Society of Civil Engineers (ASCE), the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME), American Society of Mechanical Engineers (ASME), American Society for Engineering Education (ASEE), American Institute of Chemical Engineers (AIChE), and National Councils of State Boards of Engineering Examiners (NCSBEE), and approved a charter which became that of the Engineers Council for Professional Development (ECPD). The immediate object of ECPD as stated in the charter and rules of procedure of that body is ". . . the development of the young engineer toward full professional competency and to establish standards whereby progress can be measured by the man, by the profession, and by the public." As the electrical engineering leader in the activities of ECPD, AIEE has continuously, since 1932, evidenced its extreme concern with the development of a high rate of progress in technological proficiency in all branches of electrical engineering.

Student Branches Activities

Through its Student Branches activities, the AIEE brings to the college campus (at an expense which is estimated at $100,000 for the coming year) a keen sense of technical responsibilities. With this program, it encourages the young engineer to express his technical skills through the written and spoken word, and it does not limit this encouragement to any special segment of the engineering art.

In the administration of this student program, a Student Branches Committee of over 30 members, working without pay, gathers together in whole or in part several times each year for the sole purpose of studying the problems of the student engineer in an effort to develop more effective means of solving these problems.

Breadth of Activities

Technologically, the affairs of the institute cover an area which is broad indeed. Typical of its technical committees are those on: "Television and Aural Broadcasting Systems," "Communication Theory," "Feedback Control Systems," "Electronic and High-Frequency Instruments," "Telemetering," "Computing Devices," "Electronics," "Power Generation," "Production and Application of Light," "Industrial Power Systems," "Industrial Power Rectifiers," "Industrial Control." These are but a few of the broad and extensive areas in which the Technical Operations Department of the AIEE shows its concern with the technology of all phases of electrical engineering.

The extensive activities of the Institute in the intricacies of electrical technology have established it as an international authority on electrical standards. Specifications and standards prepared by the various technical groups in the Institute are the foundation for manufacturing standards for electrical equipment in the United States and abroad.

The Engineering Societies Library is the finest collection of published engineering material in the world today. It is operated by AIEE, ASME, ASCE, and AIME for the sole purpose of insuring that engineers will never want for a storehouse of technological information.

Publicationswise, the printed pages produced by the various publications of the Institute are in general split approximately 50-50 between the broad fields of electronics and power.

Cultural Activities

During the many decades of demonstrating its concern for the status which will be yours after graduation, AIEE is attempting with equal fervor to follow a program in which your cultural fullness can be utilized to the utmost. For over six decades, the AIEE has been developing a program specifically aimed at bringing students into contact with their fellows in a manner which will encourage free exchange of ideas, and a willingness to coexist with seemingly clashing personalities.

Through its program of Student Branches, their committee activities, and their social gatherings (the ideas for which originated in electrical engineering with AIEE), there has been established, at great expense to countless individuals, a medium for the development of cultural fullness in student engineers which was not available in electrical engineering until established by the AIEE.

In the Student Branches Committee of the AIEE, there are some 13 subcommittees in which thousands of man-hours of unremunerated time is expended annually for the sole purpose of endeavoring to discover students' needs and to make available to them these necessities.

A Subcommittee on Publications grapples with the problem of how best to serve student reading interests. A Subcommittee on Prize Paper Competitions endeavors to improve the program of student papers contests. A Sections Co-ordination Subcommittee diligently tries to create conditions under which the undergraduate student can have more wholesome and beneficial contacts with practicing engineers. A Subcommittee on Summer Student Programs pursues the problem of how best to insure that the prize paper winners at the Summer General Meeting of the Institute will be assured of getting maximum possible benefit from that experience. All these and others work devotedly year in and year out, sole motivation being ultimate improvement of the professional environment into which the student will graduate.

Against the foregoing background of destruction and construction, attack and counter-attack, it does seem ridiculous indeed that we should endeavor to justify our invitation for your participation on the basis of a few paltry pounds of reading matter.

When you consider the vast amount of work that others have been doing over a period of more than half a century, work designed solely to make yours a better professional world, $5 is a paltry contribution to make; it is, indeed, so little that you will combine the paying of it with a request for a specific job assignment in your student branch.

Electrical Engineering Education

POWER SUPERSONICS RADIO TV EHF LIGHT X-RAY NUCLEAR ENERGY

Determining the Equivalent Circuit of a Transformer by Matrix Methods

W. L. CASSELL
MEMBER AIEE

THE EQUIVALENT CIRCUIT of the iron-core transformer is usually presented as fact, with but a casual attempt at justification of the circuit configuration or the values of the parameters. It is the purpose of this article to start with the transformer as a 4-terminal network of measurable parameters and to develop therefrom the conventional equivalent circuit by means of matrix algebra.

Fig. 1 represents the transformer in terms of measurable self-impedances Z_{11} and Z_{22}, and the mutual impedance Z_{12} which may be found by short-circuiting winding 1 and measuring the impedance Z'_{22} looking into the two open terminals.

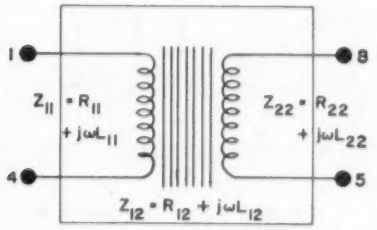


Fig. 1. The iron-core transformer as a 4-terminal network.

The mutual impedance may then be found from the relationship

$$Z'_{22} = Z_{22} - \frac{Z_{12}^2}{Z_{11}} \qquad (1)$$

The Z matrix of the transformer of Fig. 1 is

$$\begin{Vmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{Vmatrix} = \begin{Vmatrix} R_{11}+j\omega L_{11} & R_{12}+j\omega L_{12} \\ R_{12}+j\omega L_{12} & R_{22}+j\omega L_{22} \end{Vmatrix} \qquad (2)$$

This 4-terminal network may be broken up into the two series-connected networks of Fig. 2. At the moment, R_1, R_2, L_1, and L_2 are undefined, except that each must be less than the corresponding double-subscript parameter.

Network 2 of Fig. 2 may now conveniently be composed of two networks in cascade, as in Fig. 3. Impedance Z and the ideal transformer ratio a are unknown at this point.

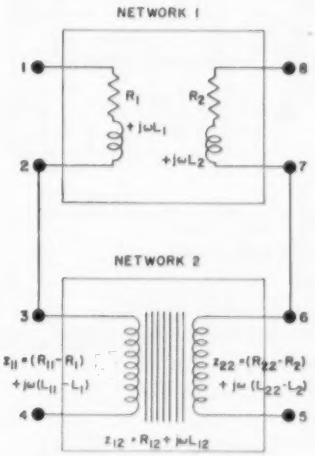


Fig. 2. The series connection of two 4-terminal networks.

Network 2 has the A, B, C, D matrix

$$\begin{Vmatrix} A & B \\ C & D \end{Vmatrix} = \begin{Vmatrix} \frac{z_{11}}{z_{12}} & \frac{|z|}{z_{12}} \\ \frac{1}{z_{12}} & \frac{z_{22}}{z_{12}} \end{Vmatrix} \qquad (3)$$

where the double-subscript impedances are defined as in Fig. 2 and $|z|$ is the z determinant of the system. That is, $|z| = z_{11}z_{22} - z_{12}^2$.

But the cascade connection of Fig. 3 has the over-all A_c, B_c, C_c, D_c matrix given by

$$\begin{Vmatrix} A_c & B_c \\ C_c & D_c \end{Vmatrix} = \begin{Vmatrix} 1 & 0 \\ \frac{1}{Z} & 1 \end{Vmatrix} \times \begin{Vmatrix} \frac{1}{a} & 0 \\ 0 & a \end{Vmatrix} = \begin{Vmatrix} \frac{1}{a} & 0 \\ \frac{1}{aZ} & a \end{Vmatrix} \qquad (4)$$

Since equations 3 and 4 are the defining matrixes of identical networks, corresponding terms may be equated, with the result:

$$\frac{1}{a} = \frac{z_{11}}{z_{12}} \qquad (5)$$

$$0 = \frac{|z|}{z_{12}} \qquad (6)$$

$$\frac{1}{aZ} = \frac{1}{z_{12}} \qquad (7)$$

$$a = \frac{z_{22}}{z_{12}} \qquad (8)$$

From equation 5, $z_{11} = \frac{z_{12}}{a}$

$$(R_{11} - R_1) + j\omega(L_{11} - L_1) = \frac{R_{12}}{a} + j\omega\frac{L_{12}}{a}$$

Equating reals to reals and imaginaries to imaginaries, and rearranging

$$R_1 = R_{11} - \frac{R_{12}}{a} \qquad (9)$$

and

$$a = \frac{L_{12}}{L_{11} - L_1} \qquad (10)$$

Both R_1 and L_1 have now been found

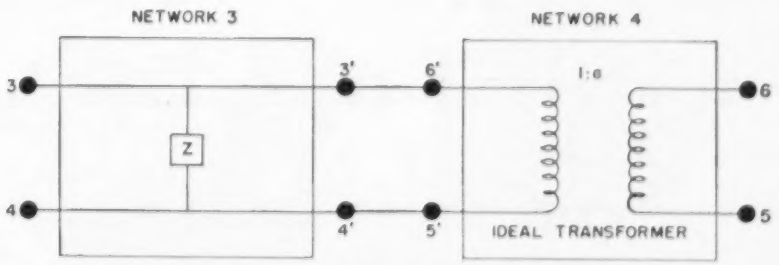


Fig. 3. Network 2 composed of the cascade of two 4-terminal networks.

A special article recommended for publication by the AIEE Educational Publications Committee.

W. L. Cassell is with the department of electrical engineering, Iowa State College, Ames, Iowa.

in terms of the original parameters, for an unspecified value of a.

By a similar process applied to equation 8,

$$R_2 = R_{22} - aR_{12} \tag{11}$$

and

$$a = \frac{L_{22} - L_2}{L_{12}} \tag{12}$$

Equations 10 and 12 are alternative expressions for a; either may be used, as convenient.

From equation 7,

$$Z = \frac{z_{12}}{a} = \frac{R_{12}}{a} + j\omega\frac{L_{12}}{a} \tag{13}$$

At this point it appears expedient to check, in equation 6, upon the necessity of $|z| = 0$.

$$|z| = \left[(R_{11} - R_1) + j\omega(L_{11} - L_1)\right]\left[(R_{22} - R_2) + j\omega(L_{22} - L_2)\right] - \left[R_{12} + j\omega L_{12}\right]^2 = \left[\frac{R_{12}}{a} + j\omega\frac{L_{12}}{a}\right]\left[aR_{12} + j\omega aL_{12}\right] - \left[R_{12} + j\omega L_{12}\right]^2 = 0$$

Conventionally,

$$Z = \frac{R_{12}}{a} + j\omega\frac{L_{12}}{a}$$

is represented by the parallel combination of a resistance R_e and an inductance L_e, with the result

$$R_e = \frac{R_{12}^2 + (\omega L_{12})^2}{aR_{12}} \approx \frac{(\omega L_{12})^2}{aR_{12}} \tag{14}$$

$$L_e = \frac{R_{12}^2 + (\omega L_{12})^2}{a\omega^2 L_{12}} \approx \frac{L_{12}}{a} \tag{15}$$

From equations 10 and 12,

$$L_1 = L_{11} - \frac{L_{12}}{a}$$

and

$$L_2 = L_{22} - aL_{12}$$

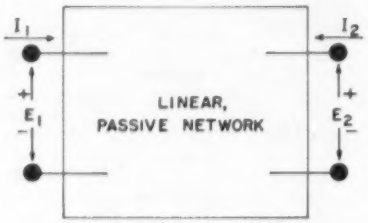
The equivalent circuit of the transformer now appears in familiar form in Fig. 4. Note the dependence of all parameters upon the turns ratio a of the ideal transformer. Inasmuch as L_{11} and L_{22} are approximately proportional to the squares of the number of primary and secondary turns, respectively, the turns ratio a may be taken as

$$a = \sqrt{\frac{\omega L_{22}}{\omega L_{11}}}$$

and the entire equivalent circuit may be built up around this value of a.

APPENDIX A

General A, B, C, D Matrix



$$\left.\begin{aligned} E_1 &= z_{11}I_1 + z_{12}I_2 \\ E_2 &= z_{21}I_1 + z_{22}I_2 \end{aligned}\right\} \tag{16}$$

$$z_{12} = z_{21}$$

Rearranging to solve for E_1 and I_1 in terms of the other two terminal quantities

$$\left.\begin{aligned} E_1 - z_{11}I_1 &= z_{12}I_2 \\ 0 - z_{12}I_1 &= z_{22}I_2 - E_2 \end{aligned}\right\} \tag{17}$$

$$\Delta = \begin{vmatrix} 1 & -z_{11} \\ 0 & -z_{12} \end{vmatrix} = -z_{12} \tag{18}$$

$$\text{Numerator of } E_1 = \begin{vmatrix} z_{12}I_2 & -z_{11} \\ z_{22}I_2 - E_2 & -z_{12} \end{vmatrix} = (z_{11}z_{22} - z_{12}^2)I_2 - z_{11}E_2 = |z|\,I_2 - z_{11}E_2 \tag{19}$$

where

$$|z| = z_{11}z_{22} - z_{12}^2 \tag{20}$$

$$\text{Numerator of } I_1 = \begin{vmatrix} 1 & z_{12}I_2 \\ 0 & z_{22}I_2 - E_2 \end{vmatrix} = z_{22}I_2 - E_2 \tag{21}$$

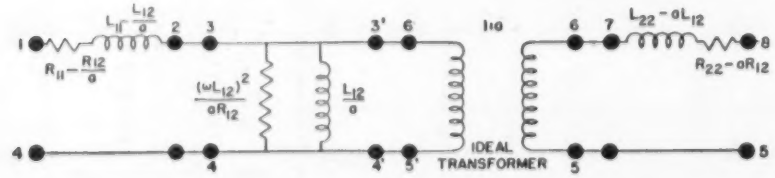


Fig. 4. Equivalent circuit of iron-core transformer.

Then

$$\left.\begin{aligned} E_1 &= -\frac{|z|}{z_{12}}I_2 + \frac{z_{11}}{z_{12}}E_2 \\ I_1 &= -\frac{z_{22}}{z_{12}}I_2 + \frac{1}{z_{12}}E_2 \end{aligned}\right\} \tag{22}$$

The following representation is convenient

$$A = \frac{z_{11}}{z_{12}} \tag{23}$$

$$B = \frac{|z|}{z_{12}} \tag{24}$$

$$C = \frac{1}{z_{12}} \tag{25}$$

$$D = \frac{z_{22}}{z_{12}} \tag{26}$$

Then

$$\left.\begin{aligned} E_1 &= AE_2 - BI_2 \\ I_1 &= CE_2 - DI_2 \end{aligned}\right\} \tag{27}$$

Obviously

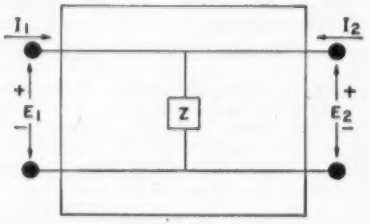
$$AD - BC = 1 \tag{28}$$

Equation 27 may be written in matrix form as

$$\begin{Vmatrix} E_1 \\ I_1 \end{Vmatrix} = \begin{Vmatrix} A & B \\ C & D \end{Vmatrix} \times \begin{Vmatrix} E_2 \\ -I_2 \end{Vmatrix} \tag{29}$$

APPENDIX B

A, B, C, D Matrix of Network 3



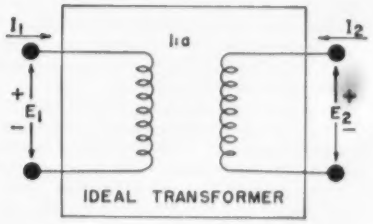
$$\left.\begin{aligned} E_1 &= E_2 \\ I_1 &= \frac{E_2}{Z} - I_2 \end{aligned}\right\} \tag{30}$$

$$\begin{Vmatrix} E_1 \\ I_1 \end{Vmatrix} = \begin{Vmatrix} 1 & 0 \\ \frac{1}{Z} & 1 \end{Vmatrix} \times \begin{Vmatrix} E_2 \\ -I_2 \end{Vmatrix} \tag{31}$$

$$\begin{Vmatrix} A & B \\ C & D \end{Vmatrix} = \begin{Vmatrix} 1 & 0 \\ \frac{1}{Z} & 1 \end{Vmatrix} \tag{32}$$

APPENDIX C

A, B, C, D Matrix of Ideal Transformer, Network 4



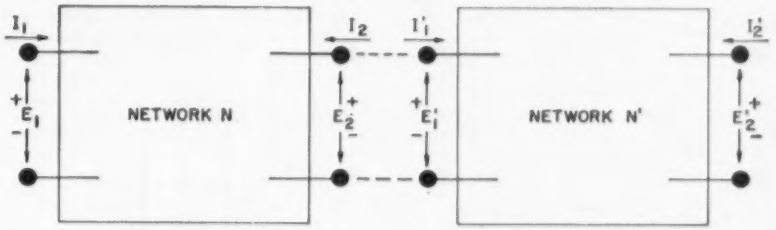
$$\left.\begin{aligned} E_1 &= \frac{1}{a} E_2 \\ I_1 &= -aI_2 \end{aligned}\right\} \quad (33)$$

$$\begin{Vmatrix} E_1 \\ I_1 \end{Vmatrix} = \begin{Vmatrix} \frac{1}{a} & 0 \\ 0 & a \end{Vmatrix} \times \begin{Vmatrix} E_2 \\ -I_2 \end{Vmatrix} \quad (34)$$

$$\begin{Vmatrix} A & B \\ C & D \end{Vmatrix} = \begin{Vmatrix} \frac{1}{a} & 0 \\ 0 & a \end{Vmatrix} \quad (35)$$

APPENDIX D

Cascade Connection of Networks



$$\begin{Vmatrix} E_1 \\ I_1 \end{Vmatrix} = \begin{Vmatrix} A & B \\ C & D \end{Vmatrix} \times \begin{Vmatrix} E_2 \\ -I_2 \end{Vmatrix} \quad (36)$$

$$\begin{Vmatrix} E'_1 \\ I'_1 \end{Vmatrix} = \begin{Vmatrix} A' & B' \\ C' & D' \end{Vmatrix} \times \begin{Vmatrix} E'_2 \\ -I'_2 \end{Vmatrix} \quad (37)$$

Since, when the two networks are connected in cascade, $E_2 = E'_1$ and $-I_2 = I'_1$,

$$\begin{Vmatrix} E_1 \\ I_1 \end{Vmatrix} = \begin{Vmatrix} A & B \\ C & D \end{Vmatrix} \times \begin{Vmatrix} A' & B' \\ C' & D' \end{Vmatrix} \times \begin{Vmatrix} E'_2 \\ -I'_2 \end{Vmatrix} \quad (38)$$

Reference

1. Communication Networks (book) E. A. Guillemin. John Wiley & Sons, Inc., New York, N. Y., vol. II, pp. 132-56.

Analog Computer Control for Compound Aircraft Machining

N. F. KFOURY
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ELECTRICAL ENGINEERING techniques are constantly providing the solution to control engineering problems which previously were insurmountable. One of the more recent applications of electrical engineering to the mechanical control field has been the design of electric analog computers for industrial machine tool control.

Computer techniques are applicable to industrial control because many machine operations such as milling, turning, and grinding can be described in terms of a mathematical equation. Any machine operation, no matter how complex, may be broken down into a number of basic mathematical processes. From this point, the solution to the problem lies in the use of an electric analog computer system for computation and control. An electric servo system, actuated by the computer output, drives the machine elements such as the milling machine spindle to its proper positions at controlled velocities.

In general, machine tools are manufacturing machines which produce finished work by removing material from a workpiece as a result of relative motion between some form of cutting tool and the workpiece. The two fundamental milling cuts in use today are illustrated in Fig. 1.

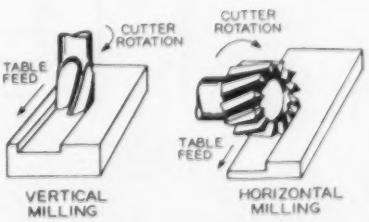

Fig. 1. Horizontal and vertical milling.

History

Manually controlled mechanical template follower machines called "profilers" have been widely used in the aircraft industry since 1940. Profilers enable machining of any two-dimensional outline on a workpiece from a template. Fig. 2 illustrates a typical profiling operation.

In 1950, hydraulic servo controlled tracing millers were being used in aircraft manufacturing to machine two-dimensional and simple three-dimensional shapes. The milling cutter had a fixed horizontal or vertical position. The table holding the workpiece could feed in all three co-ordinate axes.

Elimination of the template in favor of computer programming was investigated

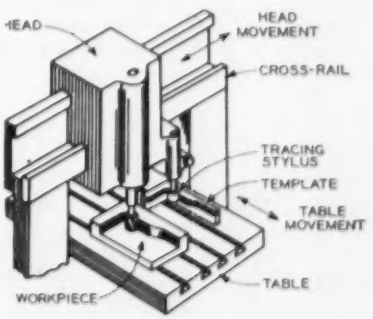

Fig. 2. Two-dimensional profiler.

Text of the paper awarded first prize in the District 3 Student Prize Paper Contest, presented at Brooklyn Polytechnic Institute, Brooklyn, N. Y., Apr. 12, 1957.

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at the Massachusetts Institute of Technology. The first phase was a basic study of the principles of computer programming. The second phase, which began in 1949, was the construction of an experimental vertical miller under contract with the

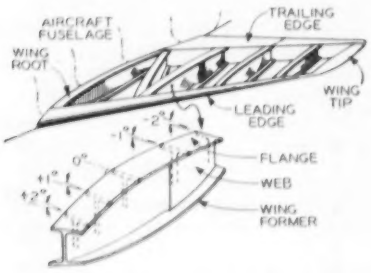


Fig. 3. Typical former structure.

U. S. Air Force. The extent of operation was simple three-dimensional cutting.

Thus far, automatic computer operation has been developed for simple three-dimensional milling with cutter in one position. Surfaces with compound curvatures require controlled angular attitude of the cutter. A solution to a unique aircraft machining problem requiring compound machining will be developed in the following sections with a design of the required computer.

The Problem

In 1951, requirements of transonic flight brought about new design of aircraft parts. Formed sheet-metal fuselage bulkheads, wing formers, and beams were replaced by high strength and low compliance structure in the form of machined aluminum alloy forgings. This enabled the cantilevered wing structure to have a higher natural frequency in both its bending and torsional modes of vibration. Periodic and random excitation of wing vibration and flutter increase rapidly as transonic speeds are approached. Complication in structural shapes are further introduced by required wing sweep-back angles of up to 45 degrees. The problem is to machine a typical wing former from an aluminum alloy billet or forging. This former is illustrated in Fig. 3. It connects the leading and trailing edges of the wing and is covered by a skin top and bottom which tapers in thickness from wing root at fuselage to wing tip.

There is a combination of airfoil camber, root to tip wing taper, and wing sweep-back angle which affects the flange contour. For reasons connected with riveting the skin and distribution of stresses, the inner surface of the flange must be of parallel contour with the complex outer surface. In machining the outside flange

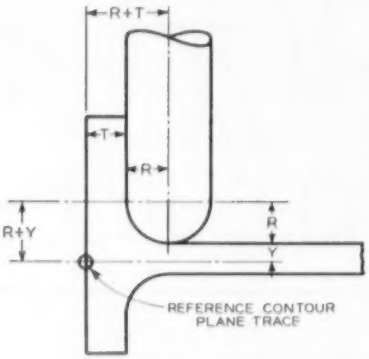


Fig. 5. Inside flange vertical cut.

surfaces, a tilting cutter must be controlled with a continuously changing angle θ. There must also be two-dimensional control similar to that of a mechanical profiler in Fig. 2 for the leading to trailing edge curvature. The depth position of the cutter need not be controlled to machine the outer flange surface as shown in Fig. 4.

The greatest problem lies in machining the outside flange surface. The following analysis will be made for only the inside surface milling operation. It will soon be apparent that the outside surface cut is a trivial problem in comparison and can be solved most readily. The inside cut is further complicated by a change in web thickness as shown in Fig. 3.

Two computer sections will be required. The first will compute lateral compensation distance for a continuously variable cutter tilt. The second will compute the correct path of the cutter for any cutter tilt occurring simultaneously with a change in web thickness. The outputs of both computer sections are lateral distance compensations and will be summed algebraically. The net value will be used as an error signal to actuate an electrical servo driving the milling head on its cross-slide. This error signal is in addition to the lateral component of the two-dimensional contour signal. The two-dimensional signal will describe the curve of the contour plane trace on the outside surface of the flange, the location of which is noted in Fig. 5. The two-dimensional motion components are resolved as the cutter head motion on cross-slide and the table feed motion normal to the cross-slide. Reference is made to Fig. 2 for orientation of these two motions.

Design of the Milling Head

The milling head design handles the compound cutter motions. Its function is to provide the means of continuously varying the angle and depth of cut. The geometry of the head and cutter, looking into the direction of the table feed, is shown in a design layout in Fig. 6.

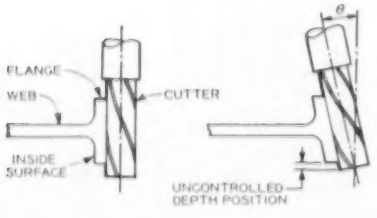
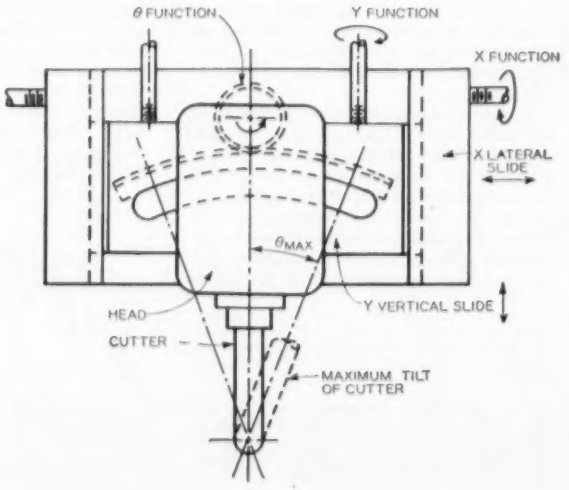


Fig. 4. Machining outer flange.

Fig. 6. Milling head design.



The cutter angle information is fed to the pinion gear driving the sector gear on the head. The angle is generated from information obtained on the wing former blueprint as a function of table feed motion in the Z direction. The rotation to obtain the desired angle takes place about the center of the hemispherical ball end of the cutter. The head moves in an arc about this center and is supported by the vertical slide. The position of the slide in the Y direction is a function of the web position and thickness and can be programmed directly from the blueprint.

First Computer Section

Nomenclature. X is lateral motion (direction of lateral correcting function); Y is distance from bottom of cutter to contour plane; T is thickness of flange; and R is radius of cut and also of ball end milling cutter.

Voltage Proportional to	
E_x	X
E_y	Y
E_t	T
E_r	R

As the milled flange angle changes, the cutter must tilt, resulting in a change in lateral position of the cutter. Fig. 5 presents the cutter in a vertical position where distance from contour plane trace on outer flange surface to the center of the ball end of cutter is at all times R plus T.

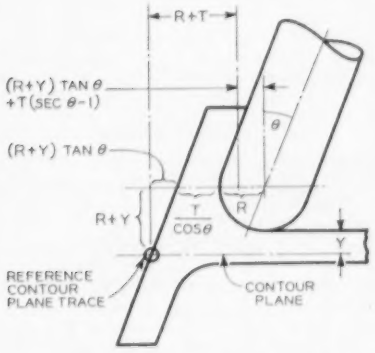


Fig. 7. Inside flange inclined cut.

In Fig. 7, the cutter is tilting at a variable angle θ and, therefore, a lateral correcting function must be considered. This will add or subtract from the $R + T$ distance depending on the algebraic sign of θ.

From Fig. 7, it may be seen that the lateral correcting function is expressed as:

$(R + Y) \tan \theta + T / \cos \theta + R - (R + T)$

or

$(R + Y) \tan \theta + T \sec \theta + R - R - T;$

this simplifies to

$(R + Y) \tan \theta + T (\sec \theta - 1).$

This function may be described by a d-c analog computer with trigonometric function generators.

The d-c analog computer must have provisions for supplying the original input voltages used in each computer section. These voltages include the input voltages for the trigonometric function generators. For this purpose, the computer may have special regulated power supplies or even battery sources for supplying these computing voltages. The power supplies in question may comprise regulator circuits essentially identical with those used in other high-voltage power supplies and designed with emphasis on good regulation and low output impedance. The load on such a power supply will vary, depending on each computer design.

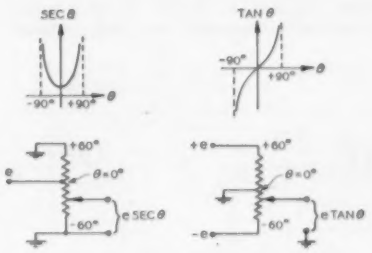


Fig. 8. Secant and tangent pots.

The output voltage of one such power supply will serve as a reference voltage E for the computer. The value of every variable voltage in the entire computer will depend on the reference voltage.

Nonlinear potentiometers will be used as the function generators. The basic potentiometer equation may be written:

$$R(\theta) = \int_0^\theta r(\theta)\, d\theta$$

where $R(\theta)$ is the accumulated winding resistance as a function of shaft angle and $r(\theta)$ is the winding resistance per increment of angle. The design problem is a matter of controlling the resistivity function so that the required output resistance as a function of the angle θ is obtained.

Resistivity may be changed by altering the spacing between individual turns of the resistance winding. A continuous change in resistivity may also be obtained by varying the length of successive turns of the winding by varying the width of the card on which the wire is wound.

A secant and tangent potentiometer will be used in the first computer section.

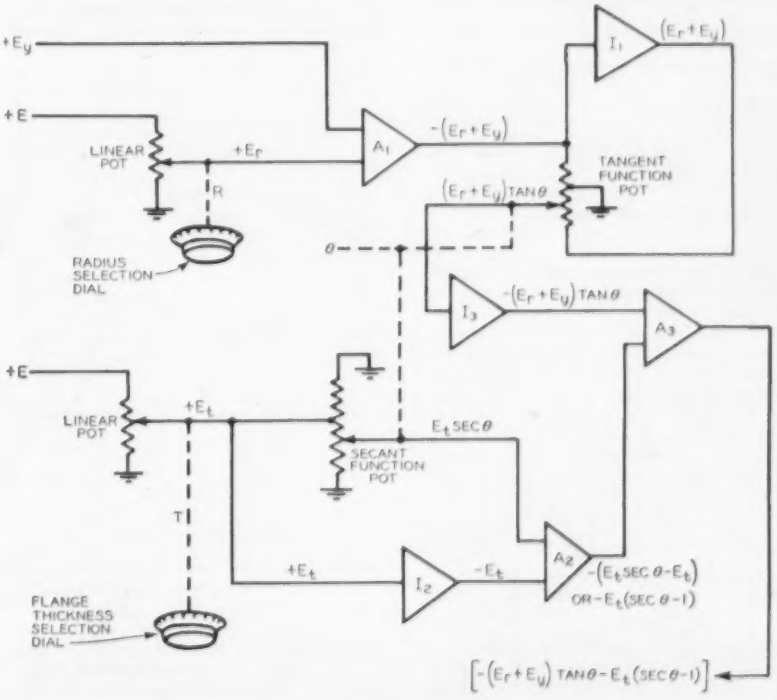


Fig. 9. First computer section.

Their circuits and functions are shown in Fig. 8. The available range of plus or minus 60 degrees is more than adequate for the cutter tilts of several degrees.

The constant reference voltage E is impressed across two linear potentiometers as illustrated in Fig. 9. One potentiometer is positioned by selection of the fixed cutter radius and the other by selection of the fixed flange thickness. If flange thickness was variable, an added input voltage varying proportionally to thickness would be used instead of a manual dial setting. Variable voltage E_y is placed into summing amplifier A_1. Note the use of amplifiers for sign changing such as I_1. High gain d-c amplifiers are used with the appropriate input and feedback elements to perform the arithmetical operations. Because negative feedback is used to obtain linearity and stabilize gain, output has opposite polarity to input. Output of this section is: $E_{x1} = (E_r + E_y) \tan \theta + E_t (\sec \theta - 1)$. This is the first lateral correction signal caused by tilting of the cutter with the Y dimension fixed. It will be summed algebraically with the output E_{x2} from the second computer section to be designed.

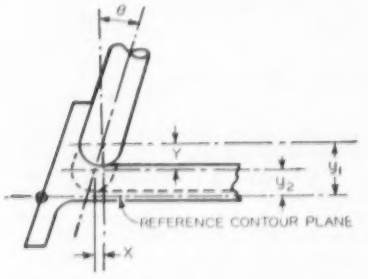


Fig. 10. Changing depth cut.

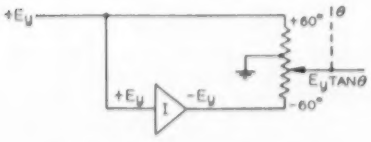


Fig. 11. Second computer section.

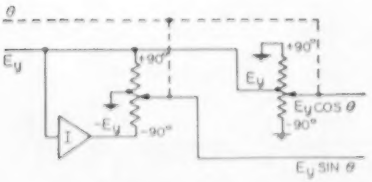


Fig. 12. Sine–cosine functions.

Second Computer Section

As the depth of cut varies in the Y direction at any cutter angle θ, the center of the cutter ball-end must move a compensating distance X. If this is not accomplished simultaneously, an irregular cut with stepped ridges would result on the inner surface of the flange. Fig. 10 shows the cutter in its inclined position at a depth distance of y_1 from the reference contour plane. As the depth changes (i.e., different web thickness) to a distance y_2 from the reference contour plane, the change in position may be called Y. Corresponding to this displacement of Y, there is a lateral displacement X in order that the cutter maintain proper alignment to the flange being machined. From Fig. 10 the lateral correcting function is simply: $X = Y \tan \theta$.

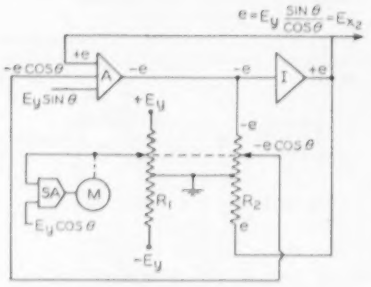


Fig. 13. Servo divider.

Inasmuch as the recently developed tangent function potentiometer is available for use, the second computer section is simply as shown in Fig. 11. E_y is obtained from the input terminal on the first computer section (Fig. 9). The potentiometer wiper arm is positioned from the sector gear drive mechanical pick-off in the first computer section.

It would be interesting to examine the solution when the tangent function potentiometer was not available because it illustrates the application of a servo-driven computer. The lateral correction signal may be expressed: $E_{x2} = E_y \tan \theta = E_y \sin \theta / \cos \theta$. The sine and cosine functions are obtained from the circuit in Fig. 12 from inputs θ and E_y.

Having the two voltages, $E_y \sin \theta$ and $E_y \cos \theta$, they are applied with the original voltage E_y to a servo-driven potentiometric divider. The voltage $E_y \cos \theta$ is converted into a setting on linear potentiometer R_1 by means of the servo amplifier (SA) driving the servo motor (M). Ganged with potentiometer R_1 is potentiometer R_2. In balancing the potentiometer R_1 against the entering voltage $E_y \cos \theta$, the servo motor turns both R_1 and R_2 through a distance proportional to $E_y \cos \theta / E_y$.

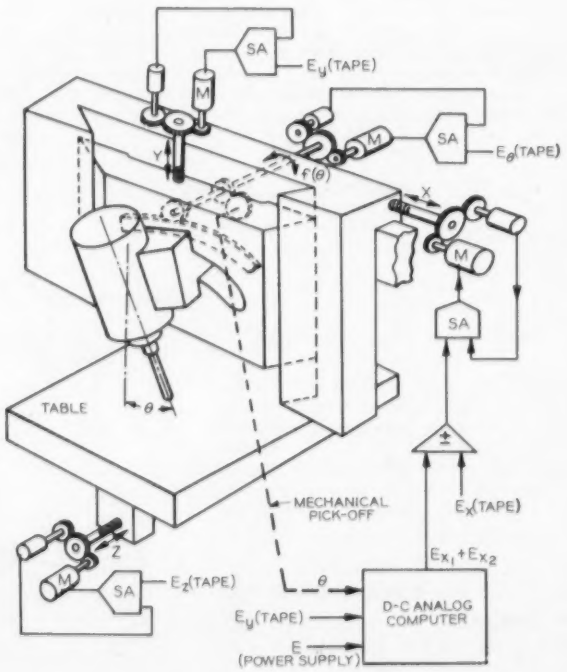


Fig. 14. Complete system.

The voltage at R_2 is then e (cos θ). This is brought into the summing amplifier with E_y sin θ and e as shown in Fig. 13.

The System

The lateral compensating voltages from the first and second computer sections are summed. This signal will then be added to the X direction signal representing the reference contour plane trace. Dimensions from the blueprint such as X lateral displacement, Z table feed position, Y vertical head depth, and θ angle of the cutter may be programmed by conventional methods on a binary tape. Of these tape signals, only E_x will be altered by the outputs E_{x1} and E_{x2} of the d-c analog computer. The entire system is presented in Fig. 14.

References

1. Automatic Feedback Control (book), W. R. Ahrendt, J. F. Taplin, McGraw-Hill Book Company, Inc., New York, N. Y., 1951.

2. Electronic Analog Computers (book), G. A. Korn, T. M. Korn, McGraw-Hill Book Company, Inc., New York, N. Y., 1952.

3. Analog Methods in Computation and Simulation (book), W. W. Soroka, McGraw-Hill Book Company, Inc., New York, N. Y., 1954.

A Demonstration Transmission Line

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STUDENT MEMBER AIEE

THE TRANSMISSION LINE described was built for use as a visual aid in the electrical engineering courses at the South Dakota School of Mines and Technology. The theory of the transmission line and its uses can be developed mathematically, but this theory appears quite abstract to the student if no demonstration of the practical uses of the transmission line are available.

Theory of Transmission Lines

The term "transmission line" is applied to any line which is employed to conduct or carry electric energy from one point to another. Any transmission line has two ends: the end to which the power is applied, or sending end; and the end at which the power is received, or receiving end. When the length of a transmission line is long compared to the wavelength of the frequency it carries, the line has certain properties different from those properties which can be accounted for by the impedance of the load in series with the line. These properties are: the inductance in series with the line, the capacitance across the line, and the conductance of the dielectric between the conductors of the line.

When a current flows through the line, magnetic fields are set up about the conductors. Any change in the current through the line changes the flux about the conductors. This change of flux induces a voltage in the line in opposition to the flux change. This inductive effect is smoothly distributed throughout the length of the transmission line, and is usually expressed in millihenrys per mile.

The two conductors of the transmission line act as plates of a capacitor, and give a smoothly distributed capacitance between the lines. The capacitance of the line usually is expressed in microfarads per mile. In the same manner, the resistance of the line and the conductance of the dielectric are smoothly distributed along the line and are expressed in ohms and mhos per mile, respectively.

If a small section of the line can be imagined to have all the properties of that section lumped together, an equivalent circuit, such as the one shown in Fig. 1,

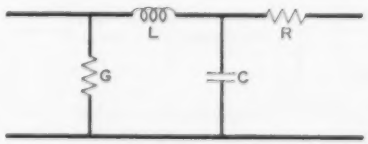

Fig. 1. Equivalent circuit of a small section of parallel two-wire line.

can be conceived. If the impedance of this small section were known, another section of the same impedance could be added and the total impedance computed. These small sections could be added on and on, and the total impedance computed each time. As the line became longer and longer, the impedance at the receiving end would change less and less until, at infinity, there would be no change in impedance. This impedance at infinite length is known as the characteristic impedance Z_0.

In transmission line theory, the a-c series impedance per unit length of the line is usually expressed as Z, and the shunt admittance as Y.[1]

$$Z = R + j\omega L \text{ ohms per unit length} \quad (1)$$

$$Y = G + j\omega C \text{ ohms per unit length} \quad (2)$$

The differential equations expressing the current and voltage of a transmission line can be compactly written as

$$\frac{dE}{dx} = -ZI \quad (3)$$

$$\frac{dI}{dx} = -YE \quad (4)$$

Two equations with two unknowns are obtained; and, to eliminate the current I, the derivative of the first equation is taken with respect to x.

$$\frac{d^2E}{dx^2} = -Z\frac{dI}{dx} \quad (5)$$

The expression for dI/dx is substituted into equation 5.

$$\frac{d^2E}{dx^2} = (YZ)E \quad (6)$$

One solution for the differential equation gives the expression

$$E = Ae^{-\sqrt{zy}\,x} + Be^{\sqrt{zy}\,x} \quad (7)$$

This solution, equation 7, can be substituted into equation 4.

$$I = \frac{1}{\sqrt{\frac{Z}{Y}}}Ae^{-\sqrt{zy}\,x} + Be^{\sqrt{zy}\,x} \quad (8)$$

$$Z_0 = \frac{Z}{Y} = \sqrt{\frac{R + j\omega L}{G + j\omega C}} \quad (9)$$

In this project, radio frequencies were used, and the effects of R and G were negligible.

$$Z_0 = \sqrt{\frac{L}{C}} \text{ ohms} \quad (10)$$

The equation for the characteristic impedance of r-f transmission lines shows that Z_0 is purely resistive, independent of frequency and length, and is expressed in ohms.

Full text of the paper awarded first prize in the AIEE District 6 Student Prize Paper Contest.

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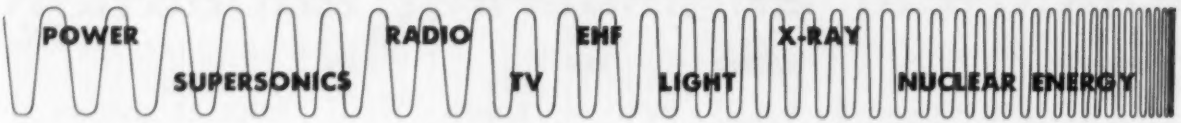


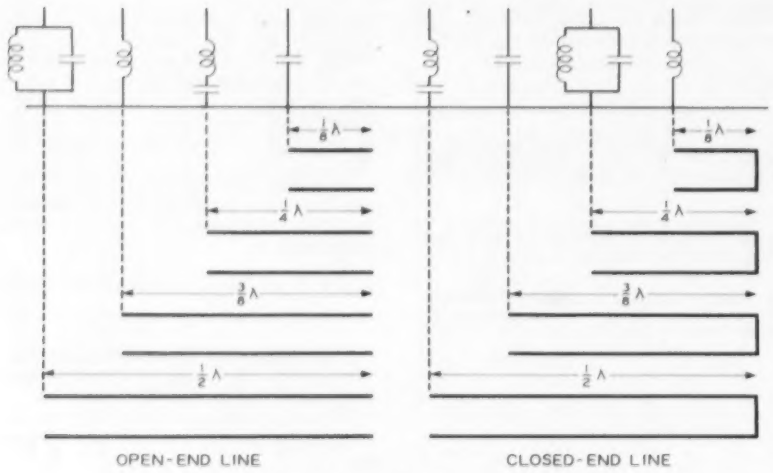


Fig. 2. Equivalent characteristics of transmission lines.

Reflection

Open-End Line. One type of r-f transmission line is the open-end line, in which the impedance at the receiving end of the line can be considered as practically infinite, inasmuch as no load is attached. For a simple explanation of reflected waves, the voltage and current of the generator feeding the transmission line are considered to be in phase. When the generator is first connected to the line, the voltage and the current travel down the line in phase with each other. The in-phase condition of the voltage and current can be changed only when they encounter a change in impedance. Thus, when the waves reach the open-circuited receiving end of the line, the current must collapse to zero. When the current wave collapses, an additional voltage is induced at the end of the line. This voltage acts as a second generator, and sets up new voltage and current waves which return to the sending end of the line.

In an open-end line, because the current is zero and the voltage is maximum at the receiving end of the line, the voltage and current waves are 90 degrees out of phase.

In addition to being 90 degrees out of phase, the voltage and current waves exist as standing waves. The beginning of a new wave starting back has the same polarity as the original wave; and the two, although varying in value, always add to produce an alternating voltage which is the sum of the two. Therefore, every point along the line has a constant value of alternating voltage; however, the value differs for each point along the line. If the values of voltage were actually plotted along the line, a curve of alternating values would form a standing wave of voltage.

Actually, the wave is far from stationary, inasmuch as the voltage at any one point is alternating from positive maximum to zero to negative maximum to zero, to a positive maximum again. The maximum amplitude of the variation remains the same.

Closed-End Line. The voltage and current relations in a closed-end line are similar to those of an open-end line. The closed-end line is terminated in a short circuit; and the current is maximum at this point, while the voltage is minimum. In a closed-end line, reflection occurs for the same reason as with the open-end line; that is, none of the energy is absorbed by the short circuit. The high current of the short circuit represents energy, and since the short circuit cannot absorb this energy, the energy must return as a reflected wave to the source.

A transmission line does not have to be of any particular length to have standing waves. The only requirement for standing waves is that the line must have reflected waves; it must not be terminated in its characteristic impedance.

Nonresonant Lines

A nonresonant line can be defined as a line which has no standing waves of current or voltage. Such a line is either an infinitely long line, or a line terminated in its characteristic impedance. The transmission line terminated in a purely resistive load equal to its characteristic impedance is said to be nonresonant.

Resonant Lines

A resonant line can be defined as a line which has standing waves of current and voltage. The line is of finite length and is not terminated in its characteristic impedance; therefore, reflections are present.

The resonant line is dependent on frequency and length for a particular characteristic. The expression "resonant at a particular frequency" means that the transmission line is acting as a resonant circuit. The line has either a high-resistive or a low-resistive impedance for a given length. When the line is open-circuited or short-circuited, and a multiple of a quarter wavelength, it acts as a resonant circuit. Lengths that are not quarter wavelengths, or multiples thereof, act as capacitors or inductors.

The half-wave, or multiple half-wave, short-circuited line will appear as a low impedance to the source. This low impedance is equivalent to the series resonant circuit. In the same manner, the half-wave open-circuit line appears as a parallel resonant circuit.

At all odd quarter-wave points (¼, ¾, etc.) measured from the receiving end, the current is maximum and the impedance is minimum in open-circuited lines. Thus, at all odd quarter-wave points the open-circuited line is acting as a series resonant circuit.

At all even quarter-wave points (½, 1, 3/2, etc.) measured from the receiving end, the current is minimum and the impedance is maximum. Thus, at the even quarter-wave points the open-circuited line is acting as a parallel resonant circuit.

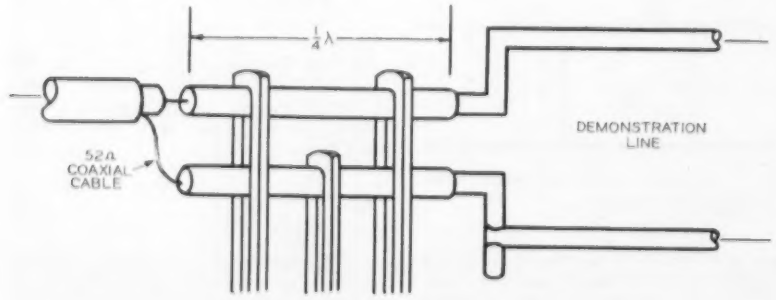
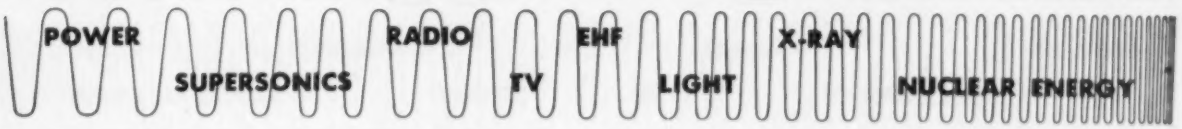


Fig. 3. Quarter-wave matching section.



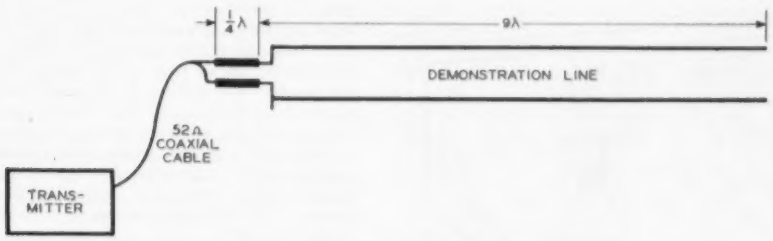


Fig. 4. Demonstration transmission line and components.

Resonant circuits constructed from open-end transmission lines follow the same general pattern, but the even quarter-wave points of the open-end line are similar to the odd quarter-wave points of the closed-end line.

Fig. 2 shows the characteristics of short- and open-circuit transmission lines. Any line, even if cut to a particular fraction of a wavelength, loses its resonant characteristics when terminated in Z_0.

Construction of the Transmission Line

A parallel two-wire transmission line was constructed for the demonstration line because of its accessibility. The transmitter used to generate the electric energy for energizing the transmission line had a wavelength of 52 centimeters. The mounting space for the transmission line allowed 9 wavelengths or 4.68 meters of transmission line to be constructed. This left enough space for the matching lines and accessories.

The output impedance of the transmitter was 52 ohms. The characteristic impedance of a two-wire transmission line is dependent upon the size of the conductors and the distance between the conductors for a particular type of dielectric. For the purpose of the demonstration line, it was desirable to use an air dielectric and separate the line about 5 centimeters. To prevent a mismatch at the sending end of the transmission line, the line must have the same characteristic impedance as the output of the transmitter. The characteristic impedance of an air dielectric two-wire transmission line is equal to 276 log b/a, where a is the diameter of the conductor and b is the distance between the centers of the conductors. A line with a Z_0 of 52 ohms must have very large conductors, in the order of 4.8 centimeters, if the centers are to be separated 5 centimeters. These dimensions would be inconceivable. A quarter-wave matching line was constructed so that a conductor of 0.635 centimeter could be used in the transmission line.

The Quarter-Wave Matching Section. In a low-loss line, a quarter-wave section inverts the normalized terminating impedance of the line.

$$Z_S = \frac{Z_0^2}{Z_R} \text{ or } Z_0 = \sqrt{Z_S Z_R} \qquad (11)$$

The characteristic impedance of the transmission line was constructed to be 276 ohms. The Z_0 of the matching line then had to be 119.5 ohms. The separating distance between the conductors of the matching section was made adjustable in order to account for temperature and humidity changes, as shown in Fig. 3.

Transmission Line. The demonstration transmission line was constructed of 0.635 centimeter copper tubing. The copper-tubing centers were placed 6.35 centimeters apart to give a characteristic impedance of 276 ohms.

The line was mounted permanently with porcelain stand-off insulators. Snap-on pins were placed at the receiving end of the transmission line so that it could be terminated with different loads, and the reactions of the line could be observed. The sending end of the line was permanently fixed to the matching section described previously.

Conclusions

The transmission line can now be terminated with different loads. If the line is open-circuited, it acts as the open-end line described earlier. The standing waves can be observed by use of neon fluorescent lamps or an r-f ammeter. Voltage and current nodes and antinodes are visible every half wave. Similarly, the line can be terminated in a short circuit and the reactions of the line observed.

The greatest difficulty is encountered in terminating the transmission line in its characteristic impedance and in eliminating standing waves. All the parameters of the circuit must be carefully adjusted to their proper values. The terminal resistance must be purely resistive and exactly equal to Z_0. The transmission line must also be matched exactly to the output of the transmitter.

Inasmuch as the current is minimum and the voltage is maximum at the open end of a shorted quarter-wave stub, the use of these stubs as insulators can be demonstrated at any point on the line. Numerous demonstrations are possible with the use of this transmission line such as insulators, reactors, impedance matching devices, and resonant circuits to mention only a few. The purpose of the line was achieved; that is, providing the electrical engineering classes with a visual aid, in order that they are better able to understand the mathematical theory presented in transmission-line classes.

Reference

1. Transmission Lines and Networks (book), W. C. Johnson, McGraw-Hill Book Company, Inc., New York, N. Y., 1950.

Two-Way Educational Closed-Circuit Television

J. R. MARTIN

CLOSED-CIRCUIT TELEVISION has been used increasingly during the last few years as a teaching medium, particularly in cases where it is necessary for a single instructor to reach a large number of students. It has been suggested that closed-circuit television provides at least a partial answer to the problem of increasingly large numbers of students in both college and secondary schools, without corresponding increases in the number of competent teachers. Studies have been made by a number of groups to determine the relative effectiveness of this medium, as compared with conventional teaching methods in which an instructor meets a small group of students in the intimacy of a classroom.

Although some of these studies have been frankly entirely subjective in their conclusions, in general they have indicated that closed-circuit television does have considerable merit in certain areas of instruction. This seems to be particularly true when used as an alternative to the large class-lecture system in which it may

A special article recommended for publication by the AIEE Educational Publications Committee.

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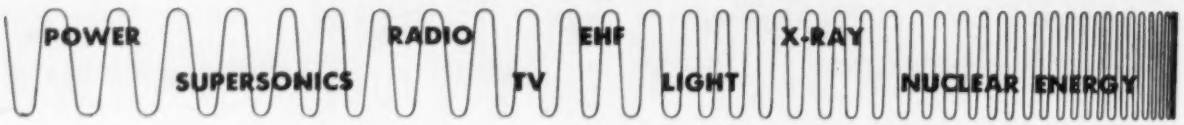
Electrical Engineering Education



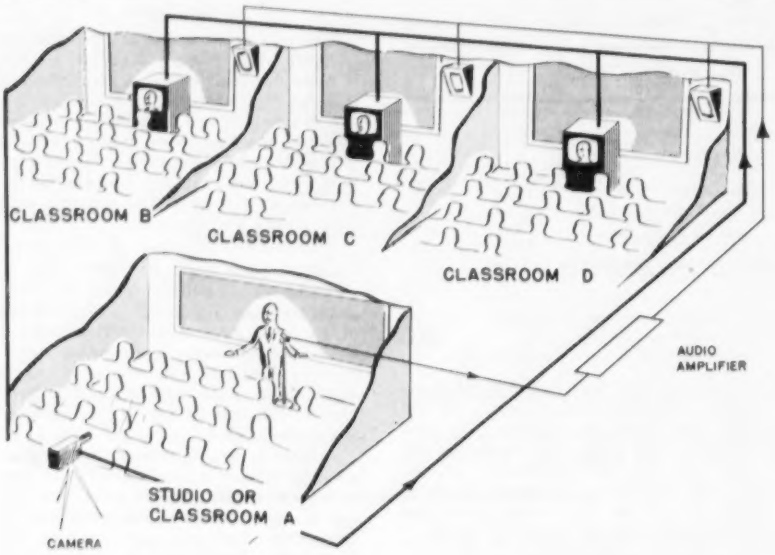


Fig. 1. Usual closed-circuit television teaching system using video-frequency distribution.

be necessary for a single instructor to lecture to several hundred students in a single large lecture room. Where the same number of students are divided into a number of smaller classrooms with one or several large-screen television receivers, a sense of identification of the student with the instructor seems to be obtained which is not possible under the usual lecture room conditions. The student who ordinarily is seated in the rear of the lecture room with a sea of heads between him and the instructor, and with numerous distractions, will instead have the illusion that the instructor is talking directly and intimately to him alone. An additional advantage to teaching by closed-circuit television is immediately evident in the case of demonstrations of scientific phenomena, in the fields of either physical or natural science. Because the television camera is capable of viewing either an over-all or a greatly magnified close-up view of operating equipment, all students have an equal opportunity to observe an experimental demonstration even better than if they were in close proximity to the equipment. Dental schools, in particular, have found this extremely useful as an aid in teaching difficult operational techniques.

There are, however, a number of valid criticisms of closed-circuit television teaching as it was generally conducted in the past. Perhaps the most important of these is that, while the student may feel a sense of identification and intimacy with the instructor, there is no reciprocal identification of the instructor with the student. If the instructor lectures from a centralized "studio" with no audience, he must address his remarks to the impersonal lens of a television camera, without being able to observe the reactions of interest, understanding, puzzlement, or boredom which a skillful instructor uses as an index of the effectiveness of his presentation. Even where, as in many cases, the instructor does have one of the groups as an audience, the students in the remote classrooms are merely observers rather than active participants in the instructional process. This condition has been improved to some extent in a number of installations by the provision of additional circuits, so that if a student wishes to interrupt the lecture with a question, he may signal his intent and establish a two-way audio contact between instructor and student. The limitations of such a method are obvious, and it is evident that conditions simulating small-class instruction are possible only if a two-way video system is also provided, so that a "person-to-person" operation is obtained.

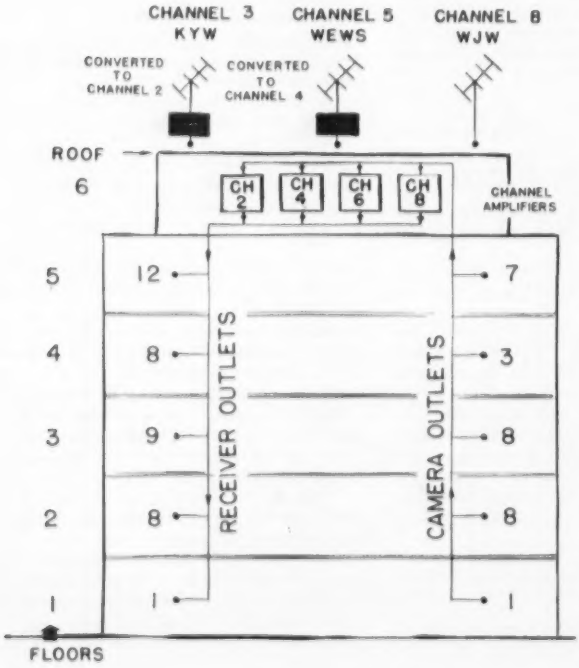


Fig. 2. Radio-frequency distribution system.

One-Way Closed-Circuit Methods

The most generally used method for closed-circuit television is shown in the diagram of Fig. 1. The image observed by the camera is transmitted to each of the remote classrooms at video frequency* over interconnecting lines, while the sound is transmitted over the audio circuits as

* In video frequency transmission, the video information is transmitted directly with a frequency bandwidth ranging from about 20 cycles to 6 megacycles.

shown. All programs must originate at the central location. If it is desired to originate a program from additional locations, then the system must be duplicated for the second program. Although it is possible to have two-way video operation between the classrooms and the instructor, this would necessitate a second video line between the instructor and each classroom in which a camera would be located. Even two-way audio contact, when at loudspeaker level, requires either two separate audio lines or elaborate switching and signaling systems, or possibly two-way balanced repeating amplifiers. Any signaling or control systems which might be found useful at either the classroom or the instructor position require separate circuits for each signal transmitted.

Two-Way Television System Details

The use of radio-frequency rather than video-frequency distribution overcomes the difficulties suggested in the foregoing method, and provides extremely flexible operation, not only for use in teaching, but also in providing facilities for a number of other useful applications. In this method, the video output of the camera amplitude modulates a radio-frequency carrier generated at the camera location. This modulated carrier, which also carries frequency-modulated sound, is then transmitted to any point over a coaxial cable distribution system, in much the way that television programs are broadcast by commercial television stations. Since any radio frequency can be chosen as the carrier, any number of separate information signals can be transmitted within the transmission limitations of the coaxial lines. For the transmission of video information, the simplest method is to use standard vhf television broadcast carrier frequencies. This permits any commercially available television receiver to be used not only at points remote from the camera, but also as monitors wherever desired. If the distances are so great that transmission losses are appreciable, a centralized unattended amplifier can be provided, either broadband or tuned to each of the channels in use.

The development of radio-frequency distribution systems for closed-circuit television has been described by M. H. Kraus.[1] One such system, as installed in the Electrical Engineering Building at Case Institute of Technology, is shown in block form in Fig. 2. In this installation, 27 camera input positions distributed throughout the building are connected over a single coaxial line to a central unattended radio-frequency amplifier. This amplifier consists of four amplifying strips, each tuned to a separate 6-mc band. The bands used are those of commerical channels 2, 4, 6, and 8. These were chosen because they include commercially available television bands in Cleveland. Separate Yagi antennas are available if reception is desired from these stations, although such reception is seldom used. The output from the central amplifier is fed over a second coaxial cable system to 38 receiver positions. Since standard commercial receivers can be tuned to any one of the available channels, it is evident that as the system is presently used, four independent cameras can operate simultaneously over the system, together with the sound originating at each camera position. It is, of course, possible to add selective amplifiers for channels 10 and 12, thus providing for six programs with a band of at least 4 mc separating each channel.

The possibilities of using the system for two-way "person-to-person" type of instruction is immediately evident. As shown in Fig. 3, in addition to the camera at the instructor's position, a camera is located in each remote classroom. Each camera is operated at a different carrier frequency, with sound added through an audio–video mixer. A monitor receiver for each classroom is located immediately in front of the instructor so that he is at all times in direct audio and video contact with each classroom. Alternately, a single monitor can be used and switch-tuned to any camera frequency, but this may be somewhat more distracting to the instructor than the use of separate monitors. Multiple monitors can also be used in each classroom in order to permit observation of other classes as well as the instructor, if this is considered desirable. However, the presence of other monitors is apt to distract the students' attention from their instructor. For some courses, it may be desirable to have discussion between students in different classrooms. In this case, the classroom at any location need only be switch tuned to the proper camera channel, either directly at the receiver or with a remote control operated by a classroom proctor.

To preserve the illusion of personal contact, it is desirable that the cameras be placed as near to the receivers as possible. In the case of classrooms, this is achieved by placing the camera on top or to one side of the receiver. A single-lens camera without an operator may be used to view the entire class, provided the lens has a sufficiently wide angle and depth of focus. A remotely controlled camera may also be used, positioned and varied as to type of lens and focus by a proctor located in the rear of the classroom. Although the motion associated with such camera adjustments may be somewhat distracting to the class, its use permits close-up views of individual students, not possible with a single-lens camera.

In large lecture rooms, it may be found that a number of receivers scattered through the room, each serving a small group of students, will be more effective than a single large receiver at the front of the room. Large lecture rooms are not as effective for two-way operation as are small classrooms, although satisfactory operation has been obtained with remotely controlled multiple-lens cameras.

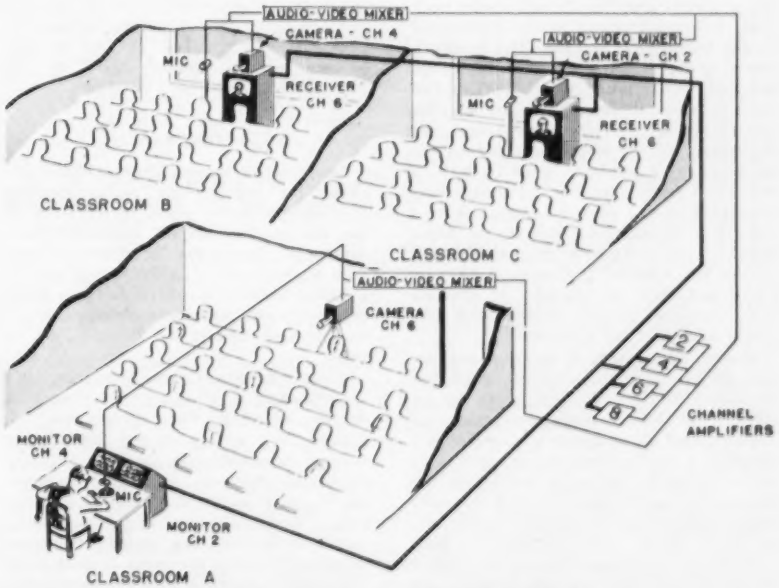


Fig. 3. Two-way closed-circuit teaching system.

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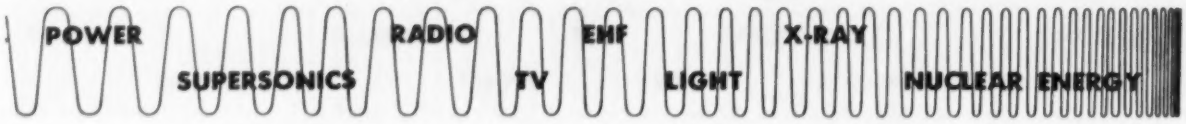


A single microphone with suitable directional properties is sufficient for the average size classroom for either one-way or two-way operation, while several correctly placed microphones will cover even a large lecture room. There seems to be no justification for the use of hand microphones passed between students, as has been used in some classroom installations with two-way audio contact. A chest or lavalier type of microphone is most satisfactory for use by the instructor. Serious acoustical feedback problems are encountered if an attempt is made to permit questions originating in one room to be heard by all other classes. Although these problems can be solved by careful microphone placement and control of acoustical levels, a simpler solution is to have the instructor repeat the question for the remote class.

To allow freedom of the instructor's movements and to provide close-ups of chalkboard material, charts, maps, etc., it is desirable to use a multilens camera at the instructor position. This camera should be operated from the back center of the room so that the instructor is looking directly at the camera when lecturing to the local class. A second multilens camera is very desirable to permit smooth transitions from distant to close-up views, although this requires more complicated switching and camera control facilities. The second camera should be capable of being rapidly changed in position and used principally for visual aids, demonstrations, and written material.

Inasmuch as any room in the building which has camera and receiver outlets is in effect a studio, it is not necessary to use a special area for the instructor position, although a central studio is provided in the installation at Case. The possibilities of special lighting and other effects are reduced, but a much more familiar and natural atmosphere is provided for the instructor. In the remote classrooms, the impression of the instructor's presence is increased, and students seem to have a feeling of active class participation rather than that of the passive observance of a theatrical production. Studies are being made to determine whether the difference in the two types of presentation has any significant effect on attitudes of students and instructors toward closed-circuit television as a teaching medium.

Room illumination is an extremely important factor in the type of instruction described. Fairly high light levels are required for vidicon cameras (almost universally used in educational closed-circuit systems) if satisfactory picture contrast is to be obtained. The use of special lighting equipment, particularly of high-intensity incandescent spots, is quite distracting and, to some extent, uncomfortable to both student and instructor. In fact, the degree of acceptance of closed-circuit television may be affected greatly by such unwelcome conditions. It has been found that overhead fluorescent lighting which gives a uniform intensity of from 60 to 80 foot-candles on a surface 30 inches from the floor is sufficient to give excellent televised images with an $f/1.5$ lens. A higher lighting level is desirable, however, because this permits the use of a smaller lens aperture with a resulting increase in depth of focus. In most cases, the installation of additional fixtures, if needed, will be found to have greater economic value than the use of special high-intensity lighting units. Rooms with outside windows should be shaded or screened to control lighting levels in various portions of the room. For this reason, inside rooms with controlled artificial lighting are preferable for both the originating and remote positions.

Program in Progress

The two-way system described has been used on an experimental basis at Case Institute of Technology for two subjects during one semester. Although there are some limitations to the operation, particularly where a large number of classes are involved, it does permit information feedback between remote classrooms and the instructor, a condition not possible with a one-way system. The studies will be continued during the next school year with particular emphasis on improvements in the technical operation of the system and the development of techniques especially suited to this type of classroom presentation.

These investigations are a part of a general study of educational closed-circuit television at Case Institute of Technology under a grant from the Committee on the Utilization of College Resources of the Fund for the Advancement of Education. Additional studies now in progress include the use of closed-circuit television as a teaching aid, modulated carrier control systems, and applications to scientific research.

Reference

1. Developments in Closed-Circuit Television, M. H. Kraus. *Electrical Engineering*, vol. 74, no. 11, Nov. 1955, pp. 974-79.

ASEE Publishes Report on Recruiting Practices and Procedures

THE TEXT of the following report entitled "Recruiting Practices and Procedures," is reprinted from a separate publication of the American Society for Engineering Education (ASEE). It also appears in the October issue of the *Journal of Engineering Education*.

Foreword

Industrial employers have actively competed for the services of engineering graduates in recent years. In the stress of the competition, certain employers have developed procedures in their dealings with students which do not appear proper to other employers, particularly to those employers who have been visiting colleges to interview seniors for 25 and even 50 years.

Complaints about those recruiting procedures came to a head at the June 1956 meeting of ASEE. The problem was considered in a session of the Engineering College Administrative Council, and was thoroughly discussed in the business meeting of the Committee on Ethics. The Society's "Ethics of Interviewing Procedures," published in 1949, had been instrumental in solving similar problems of that time. The Committee on Ethics was accordingly of the opinion that the present difficulty might likewise be overcome, at least in part, by the formulation and publication of a revised code, adjusted to new conditions.

It was expected that the Midwest College Placement Association (MCPA) would meet late in September and that the interviewing problem would be discussed. The ASEE Committee on Ethics believed that it should not proceed with the formulation of a code prior to this meeting. Arrangements were made with the MCPA for representatives of the Committee on Ethics to attend the MCPA meeting. The MCPA not only reviewed the situation, but also prepared a code for interviewing. This code was submitted to the ASEE Committee on Ethics.

In the meantime, the Committee on Ethics reported on its operations, and its co-operation with and from the MCPA to the General Council of ASEE at its November 1956 meeting. The Council authorized the Committee to proceed according to its best judgment in preparing for publication the final draft of the revised code.

The code prepared by the MCPA was submitted to the members of the Committee on Ethics and a number of changes were made in the code. The revised code was adopted by the Committee on Ethics

under the authority given by Council and it is hereby published for the guidance of college faculties, placement officers, employers, and others concerned.

Employer Responsibilities

1. The employer should contact the Placement Office long in advance so that the college can plan to accommodate all employers who wish to interview. In his original request for an interview date, the employer should explain how he wishes to organize his interviews. Employers must keep in mind that only a limited number of corporations can interview on campus at a given time, and that the scheduling of interviews is difficult.

2. Within two weeks following the interview, the employer should communicate with the student concerning the outcome of the interview.

3. The employer should give the student ample time to consider his offer before requiring a final answer.

4. The employer should provide suitable literature to give students a true picture of the corporation. This material should be supplied to the Placement Office, or to the faculty if there is no Placement Office, in sufficient quantity and well in advance of the interview date. The interviewer should clearly explain to students what tests they will need to pass, and if there will be a physical examination. He should give students complete information concerning any special requirements such as the signing of patent agreements.

5. The employer should inform the Placement Office concerning the broad categories of employment available, and the college degrees and other requirements for each.

6. The employer should accept responsibility for permanent relations with the colleges. Hence, he should conduct interviews year after year, or otherwise maintain contact with the colleges.

7. If the employer invites students to visit his plant or headquarters, he should arrange the visit to interfere as little as possible with class schedules. He should avoid elaborate entertainment and overselling. He should explain what expenses will be paid and how and when. (Many students borrow money to make these trips.)

8. The employer should send copies of all correspondence with students and faculty members to the Placement Office.

9. The interviewer should be punctual. He should tell the Placement Office when he will arrive, and he should arrive no later than the designated time.

10. No more than two and preferably only one interviewer representing an employer should appear for each interview schedule. Arrangements for more than two interviewers should be made well in advance, and only for reasons which are considered adequate by the Placement Office.

11. An employer who desires to contact a particular individual at the time of his interview visit should write that individual at least two weeks in advance, with a copy to the Placement Office.

12. The employer should not offer a student special payments, gifts, bonuses, or other inducements, nor should he compensate or favor a third party to prevail upon the student to accept a particular employment offer.

13. After a student has declined a job offer, the employer should renew his proposal only through the Placement Office. The employer is thereby prevented from annoying students who have accepted employment elsewhere.

14. The employer should invariably engage every student who has accepted the company's offer.

15. If the employer's organization is unionized, or the department for which the student is to be engaged, is unionized, the employer should tell the student if he will or will not have to join a union. Furthermore, the employer should give the student complete and detailed information as to how the union will affect his status if employment is accepted.

16. When both a parent corporation and subsidiary or affiliated corporations conduct interviews in the same college, the respective interviewers should clearly explain their missions and their connections, both to the Placement Office and to the students. Interviewers should make clear where, and by which unit or division or subsidiary corporation, the students are to be engaged.

17. Interviewers should very carefully follow the interview schedule agreed upon with the Placement Office. They should not detain any student beyond the specified time.

18. The employer should not hurry a student into making a decision concerning employment.

College Responsibilities

1. The Placement Office should inform interviewers concerning the number of students available for interview in the several curricula, and the dates of graduation. This information should be sent as soon as it is available.

2. Placement Offices should not restrict the number of interviews per student, except that they should discourage indiscriminate "shopping."

3. The Placement Office should provide adequate space and facilities for quiet and private interviews.

4. The Placement Office should announce to students at the beginning of the school year which employers will interview students and when. The Placement Office should make revised announcements from time to time as may be necessary.

5. The Placement Office should arrange for interviewers to meet faculty members who know students personally and can provide information about their work and qualifications. Such contacts should be during school hours. (The New York Engineering College placement officers strongly object. They contend that faculty members are much too busy to talk with interviewers. This opinion was expressed in a meeting of the College Federal Agency Council at the United States Military Academy in October 1956.)

6. The Placement Office should make available to interviewers appropriate records of those students who are to be interviewed. (A very few correspondents and contacts object on the ground that student records are personal and confidential and should not be made available to any persons outside the university without the student's consent.)

7. When an employer is looking for graduates in several fields, e.g., engineering, psychology, physics, the Placement Office should issue announcements to all students concerned, and schedule interviews for all those who express interest.

8. Placement officers may advise students, but should not unduly influence them in the selection of jobs.

9. Placement Offices should control distribution of corporation literature.

Student Responsibilities

1. The student should prepare properly for each interview by reading available literature, by informing himself about the employer in question, and by organizing his thoughts in order to ask and answer questions.

2. The student should use care in filling out various forms such as the standard "College Interview Form," in preparation for interviews.

3. The student should conduct himself in a businesslike manner during interviews.

4. The student should not "hoard" or "collect" job offers. As soon as he knows that he will not accept an offer, he should immediately decline it.

5. The student should not continue to present himself for interviews after he has accepted an employment offer.

6. The student should keep the Placement Office advised concerning his negotiations.

7. The student should promptly acknowledge invitations for visits to plants or corporation headquarters. He should

accept invitations only when he is sincerely interested in an offer from the employer in question.

8. The student who visits an employer's plant or headquarters for an interview should include on his expense sheet only those expenditures which actually pertain to the trip. If he visits several employers on the same trip, expenses should be prorated among them.

Adopted by the Midwest College Placement Association

Revised by the Committee on Ethics of the American Society for Engineering Education. Committee members are: C. J. Freund, *chairman*, F. T. Agthe, T. A. Boyle, Jr., W. W. Burton, A. N. Carter, N. A. Christensen, J. D. Davis, R. A. Emerson, P. M. Ferguson, J. H. Foote, J. W. Graham, Jr., L. Helander, E. F. Obert, S. P. Olmsted, R. L. Peurifoy, L. E. Rich, W. F. Ryan, C. F. Savage, J. R. Snell, W C. Van Dyck, R. W. Van Houten.

Additional Copies

Copies of this report may be obtained from W. L. Collins, Secretary, American Society for Engineering Education, University of Illinois, Urbana, Ill. Price: 25¢ per copy, 5 for $1.00; 15¢ each in lots of 50 or more.

AIEE Prize Paper Competitions Afford Many Opportunities to Students

IN THE VARIOUS Student Branches across the country, the AIEE Student Prize Paper Competitions offer Student Members unusual advantages. The student can enhance his prestige as well as that of his school, and can acquire poise as well as increased knowledge along the lines of his studies by preparing papers and presenting them in one of the regularly established competitions.

Three different classes of prizes are available each year:

(1) Within each of the Student Branches, there is a competition, the winner receiving a certificate and $10 plus a travel allowance to the District Prize Paper Competition.

(2) Within each of the 12 Districts, there is an additional competition among the winners of each of the Branch competitions within the district for the Best Student Paper. The prize consists of a certificate and $25 in cash. Additional second and third District student paper prizes have been made available from the Members-for-Life Fund consisting of $25 in cash for the second prize, and $15 in cash for third prize. Also from this Fund, the winner of the District student paper prize from each of the Districts receives a trip with all expenses paid to attend the Summer General Meeting that year. The accompanying photograph shows a group of the winners with M. S. Coover, AIEE President 1956-57, and the co-chairmen of the Students Committee at the 1957 Summer General Meeting in Montreal, Que., Canada. The Members-for-Life Fund is created by members who voluntarily continue to pay their dues after they have been members for 35 years or have reached their 70th birthday and have paid dues for 30 years.

(3) In addition, there is a National Best Student Paper Prize awarded each year which consists of a certificate and $100. This prize usually is presented at the Winter General Meeting of the AIEE. Papers are graded by juries of awards on the basis of 66⅔% for the written presentation and 34⅓% for the oral presentation.

The experience gained from the writing and oral presentation of student papers stands one in good stead for writing and presenting papers before the AIEE and other societies in later years.

Armour Landry, Photography

DISTRICT STUDENT PRIZE PAPER WINNERS attending the Summer General Meeting in Montreal, Que., Canada, June 24-28, with Past President M. S. Coover and co-chairmen of the Student Committee, included: (*seated, left to right*) N. F. Kfoury, New York University; Prof. W. H. Schippel, McGill University; Past-President Coover; Prof. Jacques Laurence, Ecole Polytechnic; J. M. Foley, University of Minnesota; (*standing, left to right*) E. T. Wright, Jr., University of Akron; L. W. Cotten, North Carolina State College; C. H. Parks, South Dakota School of Mines and Technology; R. L. Brass, Worcester Polytechnic Institute; J. T. Raleigh, Pennsylvania State University; J. D. Burroughs, Oregon State College; and R. D. Greenway, California State Polytechnic College.

New Officers of Eta Kappa Nu Announced

At the Annual Meeting of the corporation of Eta Kappa Nu Association held at Cornell University, Ithaca, N. Y., C. T. Koerner (M '53), of Glendale, Calif., was elected national president for the year July 1, 1957, to June 30, 1958. Larry Dwon of Glenrock, N. J., was elected national vice-president for the same period. C. H. MacDonald (AM '54), Upper Darby, Pa., was elected to the National Advisory Board representing the eastern region; Dr. M. B. Reed (M '43), Lansing, Mich., represents the central region; and Prof. R. E. Nolte (AM '53), Rolla, Mo., represents the western region.

Eta Kappa Nu Association is an electrical engineering honor society with more than 28,000 members in universities and in industry. Members are selected for demonstrated leadership, scholastic attainments, and extracurricular activities. For 21 years,

the society has sponsored an annual selection of the Outstanding Young Electrical Engineer, not more than 35 years of age. Since the universally acknowledged shortage of engineers, it has been sponsoring the presentation to high school students of a movie, "Engineering—A Career for Tomorrow," to portray properly to these students the possibilities in electrical engineering.

The Annual Meeting was held in conjunction with the 65th Annual Meeting of the American Society for Engineering Education.

Lowell Tech Establishes Nuclear Engineering Course

An undergraduate course in nuclear engineering has been established at Lowell Technological Institute, Lowell, Mass., by vote of the board of trustees, Dr. M. J. Lydon, president, has announced.

The impending vast development of nucleonics for peaceful purposes will mark a new industrial revolution of unbelievable magnitude, and it is essential that Massachusetts be in the forefront of such a movement, said Dr. Lydon.

Through its program, Lowell Tech will provide the trained men necessary to the development of atomic power, radioactive tracers for research work, radiation for medical purposes, and many other uses as yet unrealized. It is expected that the reservoir of trained men will help Massachusetts become a leader in the new nuclear industry.

The four-year course will lead to the B.S. degree and will emphasize the basic sciences underlying the new science of the atom.

Westinghouse Fellowship Awarded for Study at Harvard

Joseph Cuneo, Jr., New York, N. Y., has been awarded the Westinghouse Educational Fellowship of $2,500 for two years of study at the Harvard Business School.

The award, established by the Westinghouse Educational Foundation to educate men of superior ability in the field of business administration, carries a stipend of $1,250 for each of the two years of study leading to the degree of master in business administration. The only fixed prerequisites for the fellowship are that the successful candidate must have a bachelor's degree in engineering from an accredited engineering school by the time he registers at Harvard, and that he must have the intellectual capacity, character, maturity, and ability to work with other people necessary for admission to the Harvard Business School.

Mr. Cuneo was graduated in 1957 from the Webb Institute of Naval Architecture, with a B. S. degree in naval architecture and marine engineering. He has had experience as a student trainee at the New York Naval Shipyard, as a draftsman, as an engineer, and most recently as a junior engineer for Socony-Vacuum Company.

An Electrical Engineer in Education

Yale University News Bureau—Albertus

A. G. CONRAD (AM '27, F '49), chairman of the department of electrical engineering, Yale University.

"Man is a social animal. If he is limited to a Robinson Crusoe existence, he has only one purpose in life—to re-establish contact with other members of his species. Man's need for a social existence was established in prehistoric times when it became apparent that the co-operation of individuals was a key to achievement. In facing life's battles, whether they were physical, mental, or moral, a community spirit became essential.

"When man discovered that his neighbor's bow and arrow could serve as protection to himself as well as to his neighbor, he became socially conscious. Human behavior required that he adhere to a moral code essentially consistent with that of his neighbor. This has resulted in the formation of religious groups and group worship. When man discovered that the science of medicine was more effective in fighting human diseases than witchcraft and scratching, he became interested in hospitals and community health. Gradually the social aspect of man's existence increased until the individual became increasingly dependent on a social rather than an individualistic existence.

"This community spirit prevails in the professions. The co-operation of engineers working in groups has led to great engineering achievements. The contributions of the research worker are adopted by the inventor who in turn seeks the help of the development engineer and the production engineer. Through the combined efforts of the group a useful product results. The achievement is the product of a socially minded group working toward a common objective.

"Group co-operation cannot be established without adequate systems of communications. Some communications are verbal, some can be demonstrated physically, some employ graphs and charts, and others depend on mathematical approaches. Regardless of the nature of the system of communication among engineers, co-operation has become essential. The engineer has become socially minded. Communication within small engineering groups is not sufficient. It must extend to all groups. New ideas must be exchanged. They must be subjected to discussion, criticism, and evaluation. Some of this activity can be handled in the engineering conference rooms where controversy always yields to logic. Some must have broader appraisal and this is usually arranged through the meetings of the technical societies. A technical society is an instrument of education. It is a clearing-house for new technical information and ideas. It provides communication among engineers of the developments within the profession which lead to engineering achievements. The technical society has become an essential ingredient of the engineering profession. It is essential that the engineer participate in the activity of the society. This participation is a service that the engineer owes to his employer and to his profession.

"The American Institute of Electrical Engineers is a highly organized technical society. Through its membership and its meetings, it brings together many engineers from various geographical and scientific areas. Through its publications, it presents the ideas and thoughts of the leaders

in the field. It provides, through its publications, a permanent record of the advancements in the art of electrical engineering. It provides the much needed communication between members of the engineering profession. Active membership in the American Institute of Electrical Engineers can do much to enhance the professional destiny of the young man who has chosen electrical engineering for his career."

Prof. Conrad joined the faculty of Yale University in 1928 as an instructor in the department of electrical engineering. He was appointed assistant professor in 1931, and associate professor in 1940. In 1943, he was made professor and chairman of the department of electrical engineering, director of graduate studies of the department, and Fellow of Timothy Dwight College.

An active member of the Institute, Prof. Conrad has been secretary and chairman of the Connecticut Section. He has served on the following AIEE Committees: Rotating Machinery (1948-50, 1956-57); Research (1948-51); Charles LeGeyt Fortescue Fellowship Committee (1949-52, chairman 1950-52); Student Branches (1949-50); Professional Division Advisory (1950-52); and Board of Examiners (1952-54).

Dean Everitt Receives Medal in Electrical Engineering Education

The AIEE Members-for-Life Fund Medal in Electrical Engineering Education for 1956-57 will be presented to W. L. Everitt, dean of the College of Engineering at the University of Illinois, during the 1957 Fall General Meeting of the Institute.

The Medal, which was established last year, is awarded for " . . . excellence in teaching, ability to inspire students to higher achievements, contributions to the teaching of electrical engineering in textbooks and in writings on engineering education, active participation in the work of the professional and educational societies, and contributions to teaching and the profession through research, engineering achievements, and technical papers."

W. L. Everitt

Dean Everitt held teaching posts at Cornell University, University of Michigan, and Ohio State University before joining the faculty of the University of Illinois in 1945 as head of the department of electrical engineering. He was appointed dean of the College of Engineering in 1949.

An active member of the American Society for Engineering Education, he held office as vice-president, 1953-55, and president, 1956-57.

Dean Everitt has served the AIEE as director, 1947-51, and as a member of numerous Institute committees.

NSPE Publishes Income and Salary Survey

Young engineers, chemical engineers, and engineers in education have achieved the largest gains in total earnings over the period 1952-56, and engineers employed by Federal agencies have made the smallest gains.

These are some of the findings drawn from the latest "Professional Engineers' Income and Salary Survey" published by the National Society of Professional Engineers (NSPE).

The survey, third in a series started by the NSPE in 1952, is based on an analysis of 17,000 questionnaires returned from registered professional engineers in all the technical branches.

The survey shows an increase of 21% in the median earnings of engineers during 1952-56, as indicated on the questionnaires returned. The median salary and income figure for the engineers responding in 1956 was $9,490, as compared with $7,850 in 1952.

The competition among employers for recently graduated engineers is reflected in the percentage increase in earnings for this group. Engineers at grade 3, a pre-professional level, were found to have had an increase in earnings of 28% from 1952-56, a higher increase than was noted in any of the other grades.

Chemical engineers had a median earning total of $11,000 for 1956. Civil engineers had the lowest median earnings of any of the major branches with a figure of $8,750. Other median earning figures for 1956 were: electrical $9,460; mechanical $9,780; mining and metallurgical, $10,000.

The greatest increase in earnings, dollarwise, was reported by engineers connected with educational institutions, with those engaged primarily in teaching reporting the greatest percentagewise increase. Engineers in public utilities reported the second highest dollarwise increase, while engineers in industry reported the third highest.

For all groups except state government employees, greater increases were obtained between 1954 and 1956 than over the preceding two-year period.

Engineers employed by the Federal agencies showed an earnings increase on the survey of 12% from 1952 to 1956. This increase trailed well behind percentage increases for the same period in industry, public utilities, education, state government, and county or municipal government.

A statistical breakdown on over-all earnings of engineers in 1956 shows that 90% of those replying to the survey questionnaire earned at least $6,390, as compared to a figure of $5,570 for 90% in 1954. The 1956 survey also shows that 10% of those replying earned at least $19,860. In between these two groups, the 1956 survey shows 75% of the respondents earning at least $7,510; 50% earning at least $9,490; and 25% earning at least $12,840.

On a regional basis, the 1956 survey showed engineers in the East Coast states enjoying the highest median earnings. However, a comparison of the 1956 and 1952 surveys indicates a narrowing of the regional gap in median earnings. In 1952 the median income of East Coast respondents was $1,130 higher than in the South, and $1,400 higher than on the West Coast; in 1956, the East Coast was still highest, but the difference had come down to $880 and $1,160 respectively.

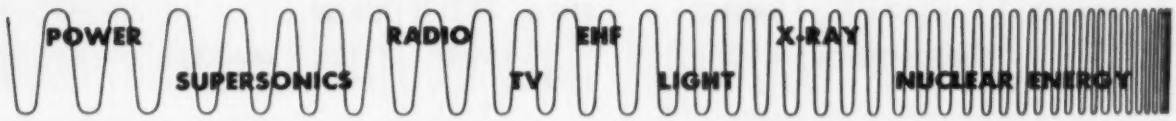
All respondents to the survey are members of the NSPE and, thus, are registered under the laws of the states and territories to practice as professional engineers. The biennial surveys are a part of a long-range income and salary study program for the engineering profession undertaken by the NSPE.

Copies of the 1956 "Professional Engineers Income and Salary Survey" may be obtained for $1 from the National Society headquarters, 2029 K St., N. W., Washington 6, D. C.

AEC Fellowships Offered in Nuclear Energy Technology

Applications are again being accepted for Atomic Energy Commission (AEC) special fellowships in nuclear energy technology. The fellowships are part of the AEC's general program of assistance in the field of education for the purpose of alleviating the shortage of trained nuclear scientists and engineers.

Fellowships are now available to students starting their work at the beginning



of the second semester or quarter, or third quarter of the 1957-58 year. The fellowship program is administered for the AEC by the Oak Ridge Institute of Nuclear Studies (ORINS), which also administers the special fellowships in radiological physics, industrial hygiene, and the ORINS graduate fellowships for the AEC.

Completed applications for special fellowships in nuclear energy technology should be submitted not later than October 15, 1957. Forms may be obtained from the Fellowship Office, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

The AEC awarded 117 nuclear energy technology fellowships for the 1957-58 academic year in March 1957 pursuant to the program announced late in 1956. As a result of the interest shown in this program, the AEC is reopening the program for the current academic year.

Fellowships carrying stipends of $1,800, plus tuition and dependency allowances, are open to students with a bachelor's degree in engineering, chemistry, mathematics, or physics, who have completed a course in ordinary differential equations. Fellows must be United States citizens. Before fellowship appointments become effective, the applicant must be accepted as a candidate for a graduate degree by an institution participating in the program. A list of these institutions is included with the application form, and applicants may make their choice from among them.

Western Electric Launches Graduate Education Program

The Western Electric Company in cooperation with a number of leading universities has launched a program of graduate education for its engineers, the cost being borne entirely by the company which is the manufacturing and supply unit of the Bell System.

The new program is equivalent in cost and administrative effort to establishment of a new engineering school of 1,000 full-time students, according to T. E. Shea, vice president—engineering.

The educational activities are being conducted on college campuses and in three specially equipped centers in New York, N. Y., Chicago, Ill., and Winston-Salem, N. C. Each of these centers include laboratories, libraries, study halls, classrooms, and related facilities. When in full operation, the program will involve a staff of some 65 full-time Western Electric instructors and administrative people, and about an equal number of instructors recruited on a part-time basis from the faculties of co-operating universities. About 2,000 students per year will engage for periods of time in full-time off-the-job study.

Presently, six universities are co-operating in the program: New York University, Northwestern, Illinois Institute of Technology, Cornell, Duke, and North Carolina State. It is anticipated, according to Mr. Shea, that the list of co-operating institutions will be extended as the program develops.

Industry-Education Council To Improve Science Education

Nearly 100 national leaders in science, education, and industry cut short their Fourth of July weekend on July 7 to gather for a week-long national industry–education conference at Lake Arrowhead, Calif. Their purpose was to take a cool and clear look at the nation's scientific manpower shortage, and decide how industry and education could best co-operate to end it. Sponsors of the conference were the National Academy of Sciences and Hughes Aircraft Company of Culver City, Calif.

For five days the conference delegates heard national authorities outline the dimensions of the manpower problem, with breaks only for meals and sleep at the new University of California extension conference center where the meeting was held. Government experts like R. L. Clark, executive secretary of the President's Committee on Scientists and Engineers, warned that "the scientific manpower shortage can be ended only in the local classroom" by improved teaching of science courses from grade school through junior college. A science specialist of the U. S. Office of Education, E. S. Obourn, pointed out that the number of new science and mathematics high school teachers had dropped more than 50% between 1950 and 1954, and only now is beginning to climb slowly toward the 1950 levels.

Finally teachers, businessmen, and scientists from eight different states described local teamwork between industry and education that had improved science instruction in the nation's schools.

By Thursday afternoon, the delegates had begun to process the data through discussion groups. By Friday evening they were evolving a plan for organized industry–education co-operation that could be used first in the southern California area and then extended to other areas and communities.

By Saturday noon, when the conference adjourned, the delegates had:

Established a permanent southern California Industry-Education Council, with a full-time paid executive secretary and a five-man steering committee representing both industry and education. (Committee members: Dr. J. B. Platt, chairman, president of Harvey Mudd College in Claremont, Calif.; Dr. L. C. Van Atta, associate research director, Hughes Aircraft Co.; Everett Chaffee, associate superintendent, Los Angeles city schools; Adm. C. F. Horne, vice-president of Convair and manager of the company's Pomona, Calif. Division; and T. S. Warburton, superintendent of Fullerton, Calif., high school and junior college districts.)

Appointed five area "salesmen" within the southern California area, each with the responsibility of getting together more industries and schools to improve science teaching programs.

Okayed a drive to raise funds from industry for running the new Council and received informal assurances from industrial delegates that the needed money would be forthcoming. (Both the National Academy of Sciences and the National Science Foundation also promised financial backing if necessary.)

Agreed to publish a manual, with the backing of the National Academy of Sciences, to show other areas how to start their own industry–education co-operative programs.

Hired as the Council's first executive secretary J. T. Robinson, a brilliant high school science teacher from Whittier, Calif., with a knack of distilling complex scientific principles into simple language.

Book Describes College Laboratories

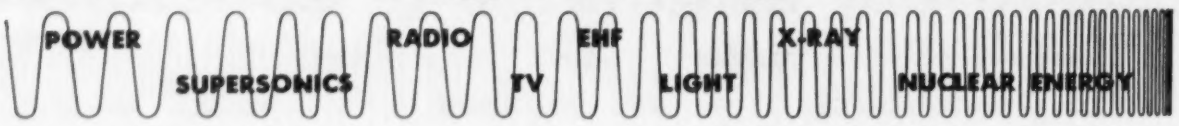
In "Designs for Laboratory Living," the Standard Electric Time Company describes installations of its "Flexlab" voltage distribution systems in more than 100 college laboratories.

The 120-page book gives complete details of power supplies, methods of distribution within the laboratory, and terminal facilities as well as descriptions of the components of the Flexlab line. It is well illustrated to show voltage distribution equipment in every type of laboratory including the newest for nuclear study.

"Designs for Laboratory Living" will be helpful to all engineering directors who may be planning new laboratories or additions to present facilities. In addition to providing up-to-the-minute information on electrical equipment, the book clearly shows the modern trend of laboratory design including lighting, layout, machinery, etc.

The Standard Electric Time Company, 239 Logan St., Springfield, Mass., will send a copy free of charge to college administrators and department heads and to school architects and engineers.

Electrical Engineering Education



Two-Week Course Offered in Engineering and Management

An Engineering and Management course, a two-week intensified program designed to prepare personnel for higher management responsibilities, will again be held on the Los Angeles campus of the University of California, January 27 to February 6, 1958, according to E. P. Coleman, co-ordinator, whose office at the University is accepting registration for the widely known course.

Study arrangements include a 10-day course from 8 a.m. to 5 p.m.; four 1½-hour instruction periods plus a luncheon meeting daily, and approximately 25 different subject offerings with a daily instruction period for each subject for the full 10 days. The total number of persons admitted and the number permitted to enroll in any subject will be controlled in order that each person may have maximum opportunity for full participation. The course is designed to be of value to most levels of engineering and management personnel. There are no formal educational requirements.

Subjects covered during the intensive study period will include General Management Principles, Engineering and Research Administration, Managerial Adjustment to Labor Law and Union Relations, Leadership Principles, the Economics of Plant Investment and Equipment Replacement, and a laboratory in Leadership, as well as specialized work in motion study and simplification of work, work measurements, and allied topics.

Information concerning course material and housing during the conference period as well as registration details, is available on request to Mr. Coleman, Engineering Extension, Room 3104, University of California, Los Angeles 24, Calif.

Reactor Engineering Group Completes Work at Union College

A milestone in the program to double the number of nuclear engineers and scientists trained by the Atomic Energy Commission (AEC) for work with the Government and private industry was marked at Union College, Schenectady, N. Y., on August 7.

The first section of the initial class of the Oak Ridge School of Reactor Technology (ORSORT)—University Co-operative program successfully wound up the first phase of its work at Union College. Other sections of this historic class completed their first-phase work during the month of August at Carnegie Institute of Technology in Pittsburgh, Pa.; Case Institute of Technology in Cleveland, Ohio; Northwestern University in Evanston, Ill.; the University of California in Los Angeles; and the University of Florida in Gainesville.

ORSORT is a graduate level school which provides both engineers and scientists with advanced training applicable to design, construction, and operation of nuclear reactor systems. Under the first half of the program, which was started in February 1957, 120 students every six months review the fundamentals of mathematics, physics, chemistry, and engineering at Union and the five other colleges and universities selected by the AEC. The remainder of the year's course consists of classified work at Oak Ridge. Before the new program went into effect only one class was graduated each year, spending the full 12 months at Oak Ridge.

Union was the only college in the entire industrial Northeast selected by the AEC for the program. Two of the members of the faculty are graduates of the ORSORT course at Oak Ridge and figure prominently in its implementation at the College.

"Union's selection for this program will enable us to expand still farther our rapidly-growing program of nuclear instruction and to continue to adjust our curriculum in the service of the nation and of private industry," was the comment of Union's President, Dr. Carter Davidson, when the AEC first announced the choice of the 162-year old college.

In-Service Science Institute Launched at New York University

A new in-service institute, an experimental project intended to interest more promising young people in scientific careers by bringing their teachers into closer touch with current developments in the sciences, is being launched this fall at New York University (NYU).

In the New York metropolitan area, 100 high school science teachers will participate in the institute, which is being organized in co-operation with the New York City Board of Education. The project has been made possible by a grant of $62,500 from the Esso Education Foundation. The grant is one of a number being made by the Foundation from funds provided by the Standard Oil Company (New Jersey) in observance of the company's 75th anniversary.

The institute will be held on 27 Saturday mornings, beginning in early October. Authorities in various scientific specialties, many of them from other parts of the country, will address the teachers.

Plans for the institute were announced jointly by Dr. C. V. Newsom, president of NYU, and Dr. William Jansen, superintendent of schools in New York City.

Discussion and laboratory work will follow each lecture, with the laboratory work designed to enable the teachers to acquire new techniques and to develop activities that can be carried back to their high school classrooms. The institute, which carries six semester hours of graduate credit, also will include field trips to demonstrate applications of scientific theories.

The participating science teachers, each of whom must have at least 10 years' experience, will receive stipends of $250 plus scholarships that cover tuition and other University fees. Present plans call for dividing the group into three sections —biology, chemistry, and physics. The sections would be brought together for lectures of general interest.

Directing the institute will be Dr. J. D. Barnard, chairman of the science education department at NYU's School of Education. Samuel Schenberg, supervisor of science for the New York City Board of Education, will assist him. They will be advised by a planning committee composed of the chairmen of the biology, chemistry, and physics departments at NYU and chairmen of similar departments in the New York City high schools.

One-of-A-Kind Sliderule Used By Blind Engineering Student

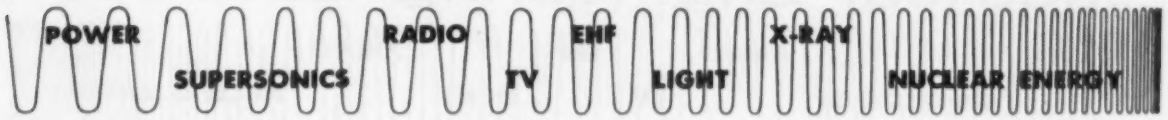
A specially-designed sliderule—easy to read by touch and probably the first of its kind ever to be made—has been produced as a gift for a blind engineering student at Manhattan College, Riverdale, N.Y., by the Keuffel & Esser Co. (K & E), New Jersey manufacturer of precision instruments.

Built for a sightless sophomore student of electrical engineering, John "Skip" Courtney, of Rockville Center, L. I., N.Y., the unique instrument employs tactile symbols in the form of raised brads systematically arranged and hammered into a 20-inch regular Log Log Duplex Decitrig sliderule.

Different in design from the standard Braille circular device used by blind students of mathematics, Mr. Courtney's sliderule is equally perceptible to touch but better enables the blind student to handle the more complicated higher mathematics needed in electrical engineering.

This sliderule was devised jointly by Brother C. Albert, instructor in electrical engineering at the Riverdale College, and A. W. Keuffel, vice-president of K & E, who supervised the development of the instrument.

Mr. Courtney has already tested the sliderule and has reported that he is "amazed with the accuracy and speed"



which he has obtained. He described his precision as being greater than the 2-4 0/0 margin for error he and Brother Albert had anticipated.

Keuffel & Esser Co. undertook to cooperate with the Manhattan College request to develop the uniquely calibrated sliderule for Mr. Courtney and presented it to him in recognition of his courage in enrolling in engineering where eyesight is normally considered essential.

Starting Salaries for Engineers Still Increasing

Starting salaries for engineers still are spiraling upward.

January and June engineering graduates at Illinois Institute of Technology (IIT) commanded an average $473 per month salary, according to E. C. Kubicek, director of alumni relations and placement.

"This is $82 more per month than the 1956 average for engineering graduates," Mr. Kubicek said.

"Salaries have increased every year since 1938, when we began keeping records," he explained. "At that time engineering graduates averaged $100 per month."

Electrical engineers again received the highest salaries—$515 a month, compared with $461 last year.

Other high department averages were: metallurgical engineering, $490; industrial engineering, $484; mechanical engineering, $473; civil engineering, $470, and chemical engineering, $458.

These figures, said Mr. Kubicek, indicate only the immediate demands for certain types of engineering skills over others. All engineering majors have been increasing steadily in starting salaries.

The over-all average, he pointed out, also included starting salaries for fire protection and safety engineering, food engineering, and mechanics.

Figures, based on a 40-hour work week, do not include starting salaries of graduates whose work experience prior to graduation exceeds one year.

Neither are statistics included for graduates who did the major portion of their undergraduate work in the IIT evening division while regularly employed, ROTC students who went immediately into the armed forces, and those continuing for graduate study.

Nearly 1,200 interviews with representatives of industry and business were arranged by the IIT placement service. Schedules were arranged for seven companies each day, representing an average of 5.5 interviews per graduate.

The placement service, explained Mr. Kubicek, regularly serves some 75% of the graduating seniors in arranging personal interviews with recruiting companies.

Novel Communication System Links SRI and Montana State

By reflecting radio signals off meteor trails, a novel experimental medium-range communications link has been established between Stanford Research Institute (SRI) and Montana State College (MSC), Bozeman, Mont. Tests have been successful in voice as well as teletype communications by the system.

Initial studies of forward-scatterings from meteor trails were performed at Stanford University. Applications have been carried out by the Institute in a research program sponsored by the Air Force Cambridge Research Center.

Operating in the 30- to 100-mc range, the two stations reflect radio signals off the meteor trails that occur about 60 miles above the earth's surface. The meteors create trails of ionized air that function like reflecting wire arrays.

The constant bombardment of the ionosphere by meteors enables the transmission of radio signals for distances as great as 1,500 miles. (The SRI-MSC link is about 800 miles.)

The communications link takes advantage of the large signals which exist when a meteor trail happens to be properly oriented in respect to the MSC and SRI stations.

Intervals between meteor trails allow intermittent transmission of messages. Therefore, for maximum use of time, messages are sent at 600 words per minute, which is 10 times the standard teletype rate.

The link employs equipment similar to that used by military and civilian agencies for short-range communications. However, by using signals reflected from meteor trails and the equipment which is specially adapted for intermittent transmission, the SRI-MSC system enables the long-range transmission of messages.

The system permits effective communications with transmitters of substantially lower power than is needed for continuous transmission on ionospheric forward-scattered circuits.

Three Chicago Area Students Win Illinois Tech Scholarships

Three graduates of Chicago area junior colleges have been named winners of scholarships at Illinois Institute of Technology.

Recipients of the one-year, full-tuition scholarships for the 1957-58 academic year are: G. E. Dietel, Chicago; C. W. Potts, and E. T. Mallory, both of Joliet, Ill.

All have selected electrical engineering as their major field of study.

The scholarships are awarded on the basis of scholastic achievement and performance on entrance examinations administered by Illinois Tech.

Similar scholarships will be awarded to graduates of junior colleges in the Chicago area in June 1958.

Robertshaw-Fulton Engineering Scholarship Awards

Robertshaw-Fulton Controls Company scholarships for four years at leading engineering colleges have been awarded to five high school graduates.

The five winners, chosen for their superior scholastic record, will study electrical and mechanical engineering. To be eligible, candidates had to be residents of counties where the company has plants. Winners also received cash awards.

Winners are: Ben Pelton, H. M. Cox, Jr., and J. P. Fort, III, all of Knoxville, Tenn., who will study at the University of Tennessee; David McCray, of Latrobe, Pa., who will attend Carnegie Tech; and H. G. Mathews, of Ligonier, Pa., who will attend Pennsylvania State University.

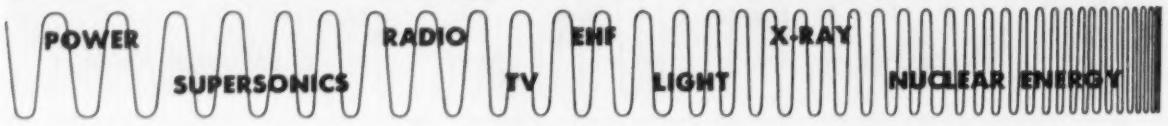
NSF Releases Report on Exchange of Graduate Students

Approximately 34,000 students from other nations were studying in institutions of higher learning in the United States during 1953-54—equal to the combined enrollment of foreign students in all universities of Western Europe. Thirty years earlier, the universities of Western Europe attracted three times as many foreign students as those in the United States.

These data are part of a report released by the National Science Foundation (NSF) on exchange of foreign and United States graduate students in the sciences, engineering, and other fields. The data are based on surveys of the Institute of International Education, New York, N. Y., and an NSF survey on graduate enrollment. The analysis is designed to complement a report of graduate student enrollments and stipends in the academic year, 1953-54, published by the NSF in the summer.

Numbers of foreign students studying at United States colleges and universities have increased steadily since World War II until, in 1955-56, 36,500 were reported, of whom 13,600 (37%) were at the graduate level. The increase is indicative of the demand for professional and technical personnel in all parts of the world, as well as the fact that United States institutions of higher learning have achieved internationally recognized status. While the majority of foreign students in

Electrical Engineering Education



this country are studying at the undergraduate level, United States Students abroad are predominantly at the graduate level.

Until 1946, the total number of foreign students at United States colleges and universities never exceeded 10,000, of which no more than 2,000-3,000 were graduate students. Since 1946, the number of foreign students in the United States has more than trebled. In 1953-54, about one third of the foreign students here were studying at the graduate level (approximately 5% of the total U. S. graduate enrollment of 250,000). They were predominantly studying in the natural sciences and engineering. On the other hand, the approximately 9,500 U. S. students abroad were primarily studying in the humanities, mostly at the graduate level.

In 1953-54, about 5,000 (50%) of foreign graduate students in America were from the following seven countries: Canada, China, India, Philippines, Mexico, Japan, and the United Kingdom. Slightly less than 3,000 of these were from the Asian countries and adjoining islands. Since 1920, Asian students have outnumbered Europeans in American institutions. While the majority of all foreign students have been from Asia, few Americans have gone to Asia to study. Of the Europeans studying in this country, the British have been the most numerous. Of Americans studying abroad, at both the graduate and undergraduate level, approximately 5,600 (60%) were in Europe and 2,800 (30%) in Canada and Mexico. The European countries chosen by most students were Italy, Switzerland, France, and the United Kingdom.

Of the approximately 10,000 foreign graduate students in this country in 1953-54, 5,150 (52%) were in the fields of natural sciences and engineering. Only 26% of all American graduate students in this country were in these fields. Of American students in foreign schools, 13% were studying natural sciences and engineering. The humanities accounted for 62%; the remaining 25% were studying psychology, social sciences, education, and other fields. In recent years, as many as 1,800 Americans have been enrolled in foreign medical schools, while only 100 foreign students were in American medical schools.

Financial support for exchange students comes from various sources—77% of foreign graduate students received all, and another 7% part, of their support from personal or nongovernmental sources; only 16% received full support, and 7% partial support, from U. S. or foreign governments. Of American graduate and undergraduate students abroad in 1954-55, 53% were estimated to have some major source of governmental or private support —32% received G. I. benefits; 11%, U. S. Government scholarships and fellowships; 6% were supported by private foundations and universities; and 3 to 4% were studying on special junior year abroad arrangements.

The aforementioned facts appear in the NSF publication "Review of Data on Research and Development, No. 4, Exchange of Foreign and American graduate Students in the Sciences, Engineering, and Other Fields." Requests for copies of this publication should be addressed to the National Science Foundation, Washington 25, D.C.

Two Rochester Students Win Stromberg-Carlson Scholarships

G. L. Budd and W. G. Frankel, both of Rochester, N. Y., have been named winners of Stromberg-Carlson scholarships, it was announced by L. C. Holmes, director of research and chairman of the Scholarship Committee at Stromberg-Carlson, a division of General Dynamics Corporation.

The scholarships will pay full tuition plus $250 a year. Both were accepted by Clarkson Institute of Technology for admittance in the Fall, where they will study electronics engineering.

Radar To See Aurora Borealis

Special radar sets, built to specifications developed by the Geophysical Institute of the University of Alaska, which is located in College, Alaska, will be operating in 10 locations in Alaska and the northern states of the United States as a part of the IGY (International Geophysical Year) program. This equipment will be directed to the task of studying the northern lights or aurora borealis during the IGY which is now on.

There will be a chain of overlapping stations in Alaska running from north to south across the auroral zone—extending from Point Barrow, the farthest north settlement on the North American Continent to Unalaska in the Aleutian Islands. Longitudinal distribution of the auroras will be monitored by a second set of stations in the northern United States in Pullman, Wash.; Rapid City, S. Dak.; and Ithaca, N. Y.

During the period of measurements, approximately 12 hundred 100-foot rolls of 16-mm film will be consumed recording the displays on the radar scopes. This particular part of the auroral radar program for the IGY is under the direction of Dr. C. T. Elvey, director of the University of Alaska Geophysical Institute and chairman of the technical panel on aurora and airglow for the U.S. National Committee for the IGY.

Army Signal Corps Sergeant Is First Enlisted Man To Get Degree

The first enlisted man in the U.S. Army who will get an opportunity to obtain a baccalaureate degree is an Army Signal Corps sergeant. Sergeant 1st Class W. B. McDonald of Vero Beach, Fla., has been enrolled by the Army at the University of Florida in Gainesville to begin working for a degree in electrical engineering.

The Army Signal Corps is planning to send other highly qualified enlisted men to various universities to work for degrees in electronics and allied fields. The complex operations of today's modern U. S. Army call for an ever increasing number of career enlisted scientific and professional personnel.

Hercules Announces 1957 Scholarship Program

For the second consecutive year Hercules Powder Company is giving unrestricted grants-in-aid to a number of United States colleges and universities—with the 1957 scholarship program totaling approximately $100,000 to be distributed among some 26 schools.

When the program was launched last year, Hercules gave $95,000 to 23 colleges and universities, giving the schools complete freedom in the use of the funds.

"The purpose of this program is to encourage American colleges and universities to provide more and better technically trained personnel so vitally needed by industry and by our nation as a whole," said A. E. Forster, president and board chairman of Hercules.

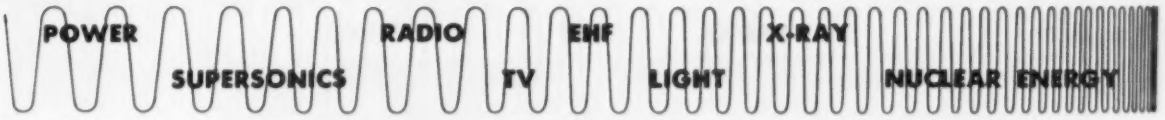
Westinghouse Establishes Memorial Professorship at Pitt

Dr. Tsung Wei Sze (AM '53) a member of the University of Pittsburgh (Pitt) engineering faculty, has been appointed to fill a new professorship in electrical engineering established at Pitt by the Westinghouse Electric Corporation.

Dr. Sze has been named Fessenden Professor of Electrical Engineering, a chair established by Westinghouse in honor of Dr. Reginald Fessenden, one of the great pioneers in the development of modern radio who was the first head of the Pitt (then Western University of Pennsylvania) engineering department and a member of the faculty from 1893 to 1900.

A native of China, Dr. Sze attended Shanghai high school and National Chiaotung University before coming to this country. He also served in the Nationalist Chinese Army from 1941 to 1946.

Electrical Engineering Education



ESCO Announces Scholarship Awards

Four people have been selected to receive scholarship awards according to a program set up earlier this year by Electric Steel Foundry Company (ESCO) of Portland, Oreg. They are R. C. Petrone, Central Catholic High School; S. F. DiZio, Gresham Union High School; Jane Berger, Mount Carmel High School, Mount Carmel, Pa.; and G. A. Pearson, student in electrical engineering at Oregon State College.

Each student will receive $600 for the first year, plus a second-year award of $400 provided he maintains a high scholarship rating and shows financial need.

Plans Announced for Addition to Moore School, U of P

Plans to erect a four-story $500,000 addition to the Moore School of Electrical Engineering at the University of Pennsylvania have been announced by Dr. G. P. Harnwell, president of the University.

With the added facilities, the Moore School will be able to accommodate increases in its enrollment and research work, which have mounted sharply in recent years and are expected to increase greatly in the next decade.

The Moore School, which conceived and built the ENIAC, the world's first large-scale, general-purpose, all-electronic digital computer, is at the southwest corner of 33rd and Walnut Sts., Philadelphia, Pa.

A feature of the new structure will be a control and instrumentation laboratory, for developing and teaching the principles involved in industrial automation.

Dr. J. G. Brainerd, director of the Moore School, recalled that modern developments in automatic control were initiated by a faculty member more than 30 years ago. He said the results marked the "first major break-through" in that field since the work of James Watt, inventor of the steam engine, and James Clerk Maxwell, famous physicist and engineer of the middle of the 19th Century.

The new building also will house a lecture hall, classrooms, staff offices, and an electromedical laboratory. This laboratory will centralize the University's work in the development of electrical aids to medical diagnosis and treatment.

For the electromedical facilities, a grant of $58,000 has already been authorized by the United States Public Health Service, to be matched by the Moore School. The balance of the $500,000 estimated cost of the building is to be sought among alumni, other engineers, and industry.

Aided also by the new structure will be the Moore School's instruction and research in telecommunications, electronics generally, computers, electric power and manufacture, photoelectric and radio astronomy.

The proposed addition will face 33rd St. and will physically join the existing Moore School building with the Towne Building, 33rd St. below Walnut St., which houses the University's Schools of Chemical, Civil, Mechanical, and Metallurgical Engineering. By linking these buildings, it will facilitate the co-ordination of the University's programs in all fields of engineering, Dr. Brainerd pointed out.

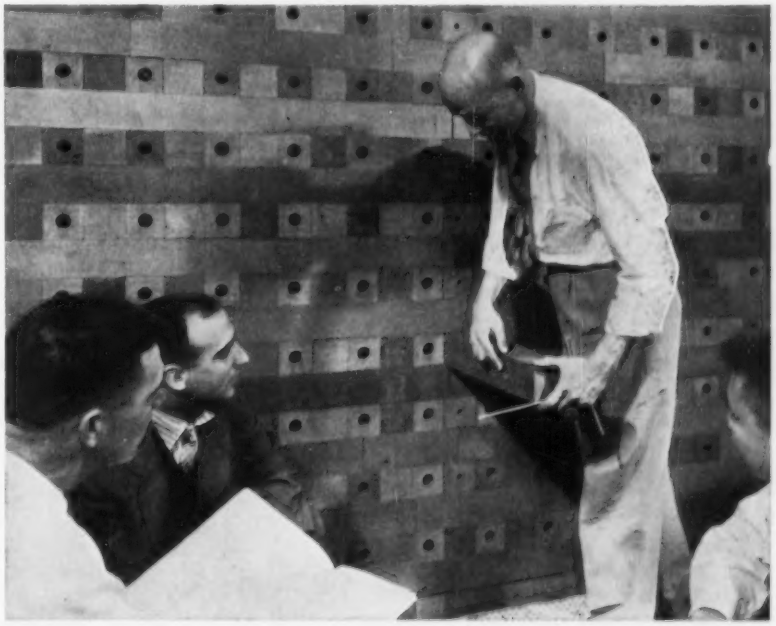
The new addition will be built of reinforced concrete, with a modern glass facade. It has been designed by the firm of Geddes, Brecher and Cunningham.

An unusual structural feature will be the use of small-module concrete floor spans, the first application of this type of construction in the Philadelphia metropolitan area.

The Moore School addition will be the ninth major building project undertaken in the University's current development program.

The Moore School, although a component school of the University, is legally and financially independent. Created in 1923 under the will of Alfred Fitler Moore, it absorbed the former electrical engineering department of the University and its students take studies in other University departments; but it has its own trustees, of whom Dr. Harnwell is now chairman.

Nuclear Graphite Goes to School



NUCLEAR FISSION is more than something in a book for graduate students of nuclear engineering at Massachusetts Institute of Technology (MIT). Working with a subcritical pile they have constructed themselves, tomorrow's atomic engineers can study neutrons behaving just as they do in full-scale reactors, with none of the radiation hazards. Dr. T. J. Thompson (*standing*), professor of nuclear engineering at MIT, discusses a laboratory test with some of his students. An indium disc will be placed in the slot he is discussing, and later will be checked with a Geiger counter in an experiment to determine the atomic activity of the pile. The natural uranium in the pile is activated by one of the first new plutonium-beryllium neutron sources to be released by the Atomic Energy Commission. Producing as many neutrons as previous sources, the new type is extremely low in gamma rays. Some 25 tons of a special grade of high-purity, high-density nuclear graphite were accurately machined into blocks by National Carbon Company, Division of Union Carbide Corporation, and graduate students at MIT assembled the 8-foot cubical pile.

Electrical Engineering Education

Argonne Graduates Its Fourth International School Class

On May 24, 1957, 47 foreign students from abroad and 13 students from the United States comprised the fourth graduating class from the International School of Nuclear Science and Engineering at Argonne National Laboratory, Lemont, Ill.

Dr. Rollin Taecker, director of the school, said that most of the graduating class left the Chicago area the following day on an inspection trip of nuclear energy research and development centers in the western United States.

The International School of Nuclear Science and Engineering was founded March 14, 1955, as a part of President Eisenhower's "Atoms for Peace" program. Since then, 162 foreign and 65 American students have been enrolled in its classes. The foreign students have represented 38 free world nations.

In co-operation with Pennsylvania State University and North Carolina State College, the International School at Argonne trains graduate and postgraduate students in nuclear science and engineering in a nine-month course.

Dr. Farrington Daniels, chairman of the University of Wisconsin chemistry faculty, was keynote speaker at the commencement. Dr. Norman Hilberry, director of Argonne National Laboratory, presented graduation certificates to the class members.

In addition to the 60 graduates, three appointees to a special two-year program at Argonne received certificates. These are carefully selected young scientists and engineers who are learning the field of nuclear science by a combination of on-the-job training and classroom work. Appointees have either a B.S., M.S., or Ph.D. degree in mechanical, electrical, or chemical engineering, or in metallurgy, ceramics, physics, or chemistry.

The curriculum of the International School includes reactor engineering, nuclear physics, chemistry, chemical engineering, and metallurgy as related to the nuclear field.

WCEMA Announces Engineering Scholarship Grants

The West Coast Electronic Manufacturers Association (WCEMA) has given 18 western universities major scholarship grants for deserving engineering students, according to C. K. Townsend, president of the organization. The donations to the schools will permit as many as 32 qualified students to attend engineering schools during the 1957-58 term.

Funds for the Annual WCEMA Scholarship Program come from donations made by member companies of the association.

Electronic executives A. F. Schwarz of Belmont, Calif.; F. E. Gilbert, Jr., of Los Angeles, Calif.; and R. T. Silberman of San Diego, Calif., headed WCEMA's 1957 Scholarship Program.

The WCEMA, which has 240 member companies located in the major industrial cities of the West, maintains offices in Los Angeles and San Mateo, Calif.

Questionnaire Checks on Engineering Aptitude

"Do I Have Engineering Aptitude?" is the title of a set of questions, answers, and interpretations of answers for use in self-analysis by young men 16 to 25 years of age to make a check on engineering and scientific aptitude. Its author is Dr. A. P. Johnson of the Testing and Guidance Division of the Newark College of Engineering, and former project director for engineering tests at the Educational Testing Service, Princeton, N. J. It is distributed free of charge by the New Jersey Engineers Committee for Student Guidance. Requests should be addressed to: Dr. F. A. Russell, Meetings Secretary, Newark College of Engineering, 367 High Street, Newark 2, N. J.

Changes Made in Carnegie Tech E.E. Department

The promotion of Dr. J. B. Woodford, Jr. (AM '53) to associate professor and assistant head of the department of electrical engineering has been announced by Dr. J. C. Warner, president, Carnegie Institute of Technology.

Dr. Woodford replaces Dr. Edward Schatz (AM '53) who has moved up to assistant dean of the College of Engineering and Science.

NSF Predoctoral Fellowship Program

The National Science Foundation (NSF) predoctoral program will be open to application in October 1957 for individuals planning to undertake graduate study in the sciences during the 1958-59 academic year. Awards will be announced on March 15, 1958.

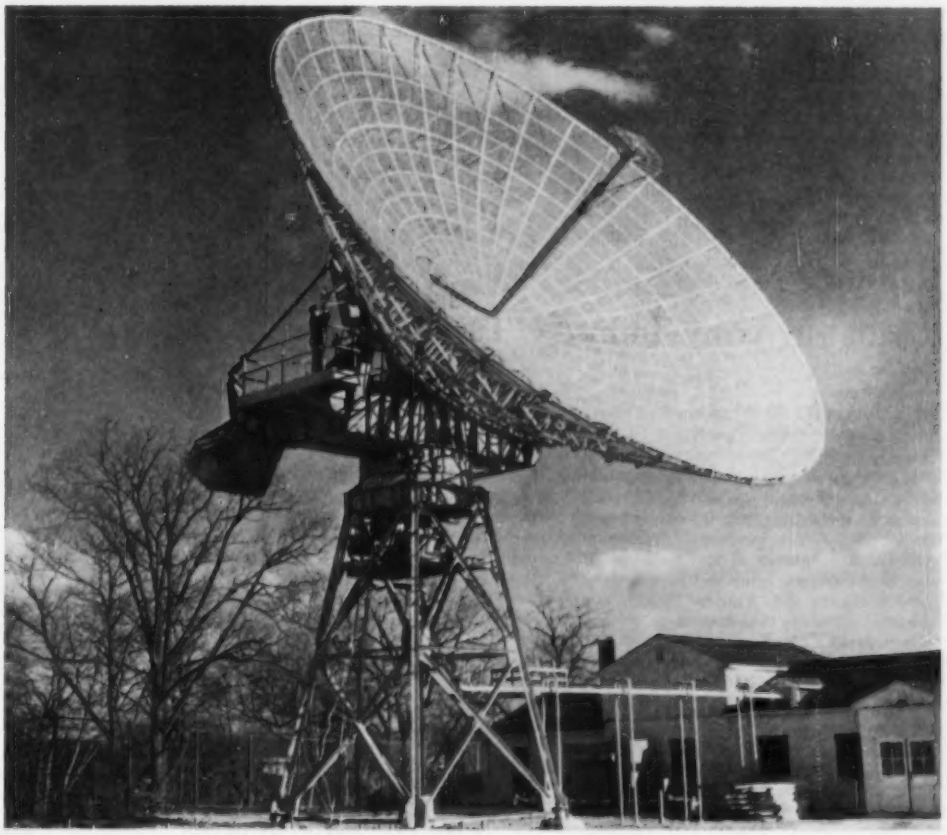
More detailed information about NSF predoctoral fellowships can be obtained in October from the Fellowship Office, National Academy of Sciences—National Research Council, 2101 Constitution Ave., N. W., Washington 25, D. C.

Newark College of Engineering Branch

Courtesy Newark College of Engineering

HENRY OTT (*center*), president of the AIEE Student Branch at the Newark College of Engineering, Newark, N. J., and Robert Stahley (*right*), treasurer of the Student Branch, present a projector and screen, a gift to the electrical engineering department, to Robert Meola (*left*), counselor for the Student Branch at the college.

OF CURRENT INTEREST



DIANA moon radar antenna, which is being used to calibrate equipment in the Minitrack stations in preparation for tracking the earth satellite, located at Fort Monmouth is presently "illuminating" the moon. This means that the huge radar is hitting the moon with a very strong signal.

"Moon" Radar Calibrates Minitrack Equipment

SIGNALS transmitted by powerful radar equipment of the U. S. Army Signal Corps at Fort Monmouth, N. J., and reflected by the surface of the moon have been received by one of the earth satellite tracking stations, it was disclosed by the U. S. Army and Navy for the first time recently.

Signals Bounced Off Moon

Using the giant radar transmitter DIANA, Army Signal Corps engineers have been bouncing signals off the moon for several years. At Blossom Point, Md., the Navy's Minitrack Test Facility has received these signals during several test "pick ups" conducted in co-operation with engineers at Fort Monmouth.

Purpose of the tests is to perfect a technique by which the operation of all of the Western Hemisphere satellite tracking stations can be tested as soon as they have been completed and placed in operation. This technique also can be used to calibrate satellite tracking stations set up by amateurs in various parts of the Western Hemisphere, Africa, Europe, and the islands of the Pacific.

World Tracking

The receiving equipment being used in the tests is the *Mark II* Minitrack being designed by the Naval Research Laboratory for use by volunteer radio tracking stations throughout the world. However, the equipment was modified because the DIANA transmitter was operated at 151 mc for these tests instead of the regular 108-mc Minitrack frequency used in the satellite tracking system.

The Navy's Blossom Point Test Facility is the first radio tracking station to be erected for detecting and measuring the path of and obtaining other information from the scientific earth satellite It is located about 40 miles south of Washington, D.C. The station, one of 10 planned for operation during the International Geophysical Year (IGY), is being operated by Project Vanguard personnel of the U. S. Naval Research Laboratory, as a part of the National Academy of Sciences earth satellite program.

IGY Stations

Other stations which will be operated by the Army during the IGY will be located at Santiago and Antofagasta, Chile; Ancon and Lima, Peru; Quito, Equador; Havana, Cuba; Fort Stewart, Ga.; Antigua, BWI; San Diego, Calif.; and Woomera, Australia.

In addition to the equipment being used to pick up signals from the moon, Blossom Point is equipped with a complete Prime Minitrack System ground station unit of the type that will be installed at all of the other IGY planned tracking stations.

The 10 Minitrack radio tracking stations, when placed in operation, will follow and report the movement of the earth satellite as it travels around the world. The stations also will pick up from the satellite scientific data concerning the experiments being conducted with instruments carried within the satellite.

Information Transmission

All of this information will be transmitted to the Vanguard Control Center located at the Naval Research Laboratory. The data will be screened and then transmitted to the Vanguard Computing Center also located in Washington, D.C.

The Vanguard Computing Center using the IBM *704* Electronic Digital Computer will map the orbit of the satellite and will calculate other data concerning the experiments (*Electrical Engineering*, September 1957, pp. 825).

Information concerning the satellite's orbit will be released through the Vanguard Control Center within a short time after the satellite passes over one of the tracking stations.

Vanguard engineers and technicians at Blossom Point have reported that many interesting results have been obtained from various tests conducted at the station. For example, the station has received signals from the sun and other solar bodies and evaluation tests also have been made by sending signals from aircraft and balloons to the ground equipment.

Redstone Missile
Result of Army-Industry Teamwork

AS A SALUTE to the International Geophysical Year (IGY), the U. S. Army's "Sunday Punch," the giant Redstone missile, was recently unveiled to the public at Grand Central Terminal. Towering almost to the ceiling, the 6-foot-diameter, 62-foot-long rocket weapon is the largest object ever displayed at the terminal. It also is the biggest missile to be successfully flown in the Western World, and already is being incorporated in the Army's arsenal as an operational weapon.

Development

The Redstone was developed by a team of Army Ballistic Missile Agency scientists headed by world-famous Dr. Wernher von Braun.

According to the Army, the weapon is a high-accuracy, liquid-propelled, surface-to-surface missile capable of bringing tremendous fire power against enemy installations. Its inertial guidance and control system, which is entirely self-contained, enables it to follow a preplanned ballistic trajectory to the target independent of outside influence. This system features special high-precision air-bearing gyros designed and produced by Ford Instrument Company, division of Sperry Rand Corporation. The system's program device receives all necessary information concerning Redstone's flight path before launching. After launching, the program device plays back signals to actuate the guidance system, thus controlling the missile as it travels to its precomputed target.

Ford Instrument Company Photo

GIANT Redstone missile recently unveiled towering almost to the ceiling of the huge, cavernous Grand Central Terminal is the largest object ever to be shown there.

Operational Versatility

The missile is described as an important weapons innovation for United States ground forces. It provides mobility, firepower, and range not possible with conventional artillery. Army sources expect to have the Redstone in operational use shortly, and are planning to arm special field artillery missile battalions with it. Already the first such unit, designated the 217th, is in training at the Army Ballistic Missile Agency which is located in Huntsville, Ala.

Largest RR Terminal Exhibit

Assembly and erection of the missile in Grand Central Station was a complex 14-hour job. Two railroad flat cars brought it from Detroit in two sections. These were assembled in the terminal and raised in upright position with special rigging equipment. Prime contractor is Chrysler Corporation. Key subcontractors are:

Ford Instrument Company, a division of Sperry Rand Corporation, which makes the guidance and control system; Reynolds Metals Company, manufacturer of the fuselage shell; and Rocketdyne, division of North American Aviation, Inc., builder of the rocket motor.

The missile was on view for from three to four weeks being precedent setting in that it was the biggest railroad terminal exhibit ever held.

Floating Zone Refining
Technique for Purification of Silicon

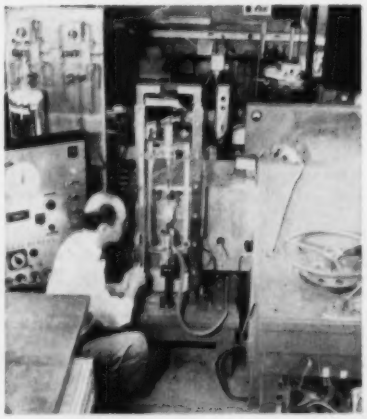
AN AUTOMATIC REFINING DEVICE which will reduce electrically active impurities in silicon to less than one part in one billion has been developed at Bell Telephone Laboratories. It utilizes the floating zone refining technique in which a molten zone is swept through the silicon, carrying impurities with it. The method can also be used to purify germanium, molybdenum, tungsten, and many other materials.

Level of Purity

The new level of purity made possible by this device may lead the way to the manufacture of improved transistors, diodes, and other semiconductor devices. It also will assist in completing an evaluation of the intrinsic properties of silicon and will permit a better understanding of conduction properties in high resistivity semiconductors.

Zone refining utilizes the fact that most impurities are more soluble in molten than solid material. Thus, a molten zone swept along a rod of silicon will accumulate impurities from the silicon. The technique is being successfully applied to refining a growing number of materials: metallic, inorganic, and organic.

No satisfactory solid crucible material has been found for containing silicon during the refining process. Fused silica, frequently used in zone refining, is attacked by molten silicon. For example, contact with commercial fused silica for one hour introduces about one to three parts per billion of electrically active impurities to molten silicon at 1,450 C. The floating zone process, however, requires no crucible and so is free from such contamination. In this process, the molten



ADJUSTING the equipment developed for automatic floating zone refining of germanium, silicon, and other materials is E. D. Kolb at the Bell Telephone Laboratories.

zone, supported only by surface tension, is passed along a vertical silicon rod rigidly held at both ends. Refining is performed in a controlled atmosphere by surrounding the rod with a water-cooled gas-tight envelope. Inductive heating produces the molten zone and motion of either the heating coil or the rod sweeps the zone along. This process is repeated, with the molten zone always traversing the rod in the same direction, until the desired purity is obtained.

Apparatus Used

The new automatic apparatus consists of a 10-kw, 4-mc generator, mechanical means for moving the rod up and down while it is rotating inside a gas-tight silica enclosure, and switching means for automatically recycling the mechanism.

Initially, because of its high resistivity, the end of the silicon rod must be heated to about 800 C by conduction from a molybdenum chuck which is heated by the radio frequency generator. Power is thereafter absorbed by the rod itself, and all subsequent operations are automatic. The power is increased to a present value, sufficient to produce the desired molten zone at a preset location, and the motor drives for the mechanism are started. These drives rotate the rod and move it downward, so that the molten zone traverses the rotating rod from bottom to top. When the zone reaches the top of the rod, a limit switch stops the rotation and decreases the power to a preset value sufficient to keep the heated but now solidified zone at about 1,200 C. This heated zone is then returned to its previous position near the bottom of the rod as the rod is raised by the drive mechanism. There a limit switch raises the power to the preset value for melting, starts the rod rotating, and reverses its direction of travel. The automatic recycling continues thereafter as long as required.

Low Current at High Frequency

Constant length and freedom from mechanical oscillation of the molten zone have been achieved by employing low heating current at a relatively high frequency and by properly proportioning the load and generator impedances. Low currents minimize electromagnetic levitation forces, the high frequency increases power transfer efficiency, and a ratio of load to generator impedance less than unity stabilizes zone length. The load impedance decreases as the rod melts so that as the zone tends to lengthen, less power is put into the load and the temperature drops, thus tending to decrease zone length. Crystals of uniform diameter are secured by control of the ratio of zone length to rod diameter so that the upward transport of material by the molten zone is balanced by the oppositely directed gravitational force.

By use of this equipment with a moist hydrogen atmosphere to remove boron, a single crystal of p-type silicon with a resistivity of 16,000 ohm-cm and minority carrier lifetime of 1,200 microseconds has been obtained after 67 passes. This corresponds to an impurity content of less than one part per billion, the purest silicon ever produced in quantity.

Developments in Aircraft and Missile Technology

Missile Blasts Missile. A new guided missile based on detection of infrared radiation is now in operation as a U. S. Air Force defense weapon. This mighty armament for protection of America's skies is the new Falcon *GAR-2A*, the latest in the guided aircraft rocket series of air-to-air missiles produced for all-weather interceptors of the Air Defense Command to protect the continent against possible enemy air attack.

News of its operational use was disclosed jointly by the Air Force and Hughes Aircraft Company at a recent Pentagon press conference.

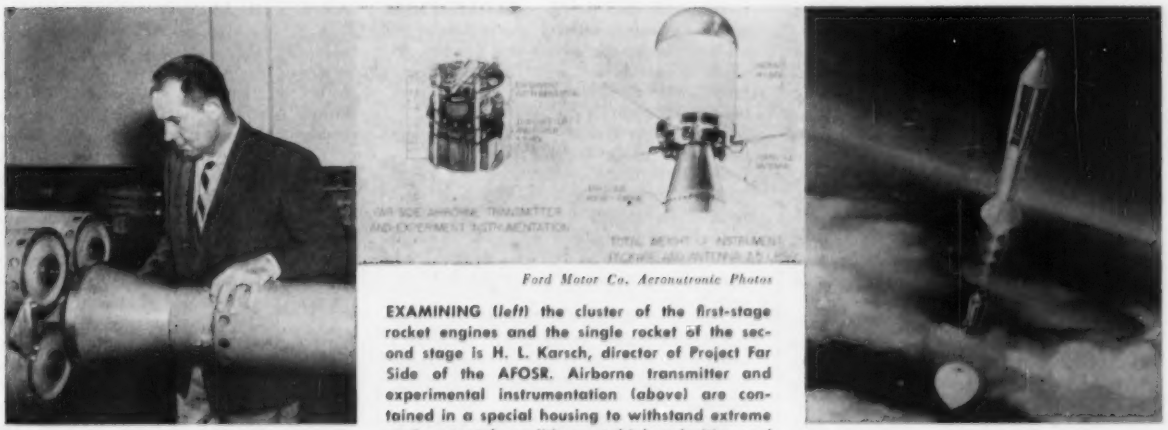
Secret of the weapon's operation is its revolutionary guidance unit which senses, at a distance of miles, the infrared radiation (IR) thrown out by invading aircraft.

One great advantage, it was pointed out, is the ability of the *2A* to be launched from far below an invader and climb to intercept it at speed far surpassing supersonic and to an altitude higher than the operational ceiling of any known bomber. The "wide-look" angle of its infrared "eye" also permits it to be launched from far to any side of the target.

Dimensions and weight of the *2A* are almost the same as those of the *GAR-1* and *1D*, being about 6½ feet long, 6½ inches in diameter and slightly more than 120 pounds. It can be fired singly or in salvo. It is powered by a rocket engine. It packs the blast of a heavy artillery shell and one hit is sufficient to destroy any known aircraft. Falcons are the smallest air-to-air guided missiles in America's weapon inventory.

Operation Far Side. A program sponsored by the Air Force Office of Scientific Research (AFOSR), Air Research and Development Command (ARDC), with Dr. Morton Alperin as the director of advanced studies for AFOSR and project monitor, in conjunction with Aeronutronic Systems, Inc., as the prime contractor, has been launched for designing, fabricating, and firing a rocket vehicle which will travel several thousand miles above the earth's surface.

The initial phase of the "Far Side" project represents the first step in a comprehensive research program aimed at obtaining information regarding the environment at great distances from the earth. Present planning calls for further experiments at even higher altitudes. It is hoped that future weapons systems programs will benefit from the Far Side project. The



Ford Motor Co. Aeronutronic Photos

EXAMINING *(left)* the cluster of the first-stage rocket engines and the single rocket of the second stage is H. L. Karsch, director of Project Far Side of the AFOSR. Airborne transmitter and experimental instrumentation (above) are contained in a special housing to withstand extreme environmental conditions at high velocities and accelerations. Turnstile antenna is shown in extended position. Artist's conception *(right)* of the firing of the Far Side vehicle shows first-stage separation. Rocket vehicle with experimental instrumention, carried high above the earth, is fired directly through the apex of the balloon.

purpose of the rocket is to investigate atmospheric and space phenomena at extremely high altitudes. The design and fabrication of the rocket vehicle and its instrumentation are being done at the Aeronutronic Los Angeles facilities.

The Far Side Project will utilize the first lighter than air rocket-launching platform to free itself from the high drag coefficient of the lower atmosphere. The largest balloon ever launched will hoist the 1,900-pound rocket to 100,000 feet before it is fired (see pictures on page 937).

The rocket, inserted into the lower end of the balloon transport, will blast upward through the balloon on firing with an initial first stage thrust of 160,000 pounds.

Flight test operations at the Pacific Proving Ground were to be started during the latter part of September of this year. These tests will involve a total of six flights. Documentation and optical telemetering of the flight tests will be covered by the Air Force's photographic center, Lookout Mountain Laboratories.

Boosted in 4 stages by a combination of 10 solid propellant rockets, the Far Side instrumentation will go through its maximum acceleration of 200 G's during its 26 seconds of powered flight. From stage four, the 6- by 4-inch instrument package and the burned-out last-stage rocket will continue upward into space as a free projectile. During its ascent and descent a miniaturized radio transmitter in the instrument package will transmit measurement of cosmic rays and other data to ground receiving and recording stations. Data will be obtained from these experiments on the nature and origin of cosmic rays as well as the anomalies of the earth's magnetic field.

Acoustic Test Lab. As the thrust and Mach numbers of airplanes and missiles increase, the attendant rise in acoustic power often results in sound pressure levels high enough to affect the reliability of mechanical and electrical components. These components must undergo functional tests in high-intensity sound chambers having an acoustical excitation with sinusoidal or random noise.

Different types of equipment, such as plane wave tubes and resonant and reverberant chambers, help Bell Aircraft Corp. engineers to run a variety of definitive tests on the many complex units that go to make up today's missiles and airplanes. Sound pressure levels up to 160 db for discrete frequency and up to 145 db for random noise are provided over test areas up to 250 square inches.

Sound test equipment consists of an anechoic chamber high-intensity microphones, multichannel tape recorders, and various filter analyzers. This makes possible the recording and analyzing of engine noise during ground and flight tests, the playback of the recorded noise into sound chambers and the calibrating of sound instrumentation.

Improved Aircraft Altimeter. An electronic altimeter, accurate to within 40 feet at 60,000 feet altitude, has been developed for the U. S. Air Force by the Air Research and Development Command (ARDC). It will replace the electronic altimeter now being used by the Air Force.

Designed for navigation, the altimeter also will be useful in aerial reconnaissance work, and for other applications where exact altitude above the earth's surface is a necessity in the accomplishment of a mission.

The new altimeter determines an airplane's altitude by sending a radar signal to the ground and measuring the time it takes to return. This time then is transposed into feet, and servomechanisms display the altitude on a standard altimeter dial.

The present electronic altimeter uses a cathode ray tube for its presentation, requiring an operator to read the scope and interpret it. The new instrument—designated *APN/12*—not only gives an immediate reading, but also can put readings from its servo amplifiers on as many as three dials at once, and can be used to feed information to recorders, potentiometers, and other devices.

The *APN/12* is contained in three units. The radar transmitter, receiver, and antenna unit will fit in a slot in the bottom of the airplane. The control amplifier, containing the servo amplifier and timing circuits, can be placed anywhere in the airplane, and the 3¼-inch-square indicator will fit easily into the instrument panel. The scope used by the present altimeter requires an opening 6½ inches by 6¾ inches, and a depth almost twice that of the *APN/12* indicator.

Firing of HAWK *and* NIKE *Missiles Coordinated.* Missile Master, an electronic system for controlling and co-ordinating fire of NIKE anti-aircraft batteries, will also co-ordinate the HAWK, a recently developed low-altitude air defense missile and other advanced Army weapons as they become available, the Department of the Army announced today.

The Missile Master, a U. S. Army Signal Corps development, is manufactured by The Glenn L. Martin Company, which has completed a study contract to tie the HAWK missile into the system. The HAWK is capable of destroying attackers flying at even the lowest altitudes and will complement the defense against high-level air attacks provided by the Army's NIKE system, thus giving the nation all-altitude defense against aerial attack.

It collects information on the location of aircraft and their identity, presents this information on electronic displays and distributes this data to the missile firing batteries. Operators observe the activities of all batteries in the system and are able to direct a specific fire unit to a particular target, or to prevent friendly aircraft from being fired upon by our own weapons.

The Missile Master operates in connection with the Air Defense SAGE system.

Missile Nose Cones Pass Re-entry Tests. The U. S. Air Force has disclosed that "numerous ballistic missile test nose cones" have been successfully brought through the blazing inferno of atmospheric reentry on flights of the Lockheed *X-17* research rocket.

The *X-17* is the test missile to prove nose cone design under flight conditions similar to those which will be encountered by the nation's intercontinental ballistic missiles.

With the unveiling of the powerful *X-17*, Lockheed displayed a missile nose cone similar to those that have penetrated the earth's atmosphere in the tests. Scientists state that the nose cones are among the smoothest surfaces ever created by man.

The three-stage test missile, built by Lockheed's Missile Systems Division in Van Nuys, Calif., is the biggest and most powerful vehicle in existence using all solid propellants.

A 40-foot tall projectile, the rocket's first stage is a single large solid propellant, the second stage is a cluster of three Recruit rockets, and the third is a single Recruit, all built by Thiokol Chemical Corporation. The first stage blasts the six-ton "bird" off the launching pad at the Air Force Missile Test Center, Cape Canaveral, Fla., to an altitude of several miles in a few seconds, while developing a thrust equivalent to 500,000 hp.

The rocket then follows a looping trajectory, coasting upward to its peak altitude in the thin air of the ionosphere. Without sufficient air to provide aerodynamic control, it drops tail-first to an altitude where denser air begins to turn its nose down.

In the heavier air the rugged vehicle is pointed nose down and ready for the most arduous part of the journey. At this point, the first stage is ejected and the second stage is ignited. The missile again roars into life and starts an accelerated, headlong plunge through the atmosphere.

In just a few seconds the second stage has belched out a tremendous surge of power—more than 1.5 million hp—and is discarded. Simultaneously with the ejection, the third and final stage, with the nose cone, fires and drives the *X-17* downward at an even more fabulous speed, subjecting the nose shape to extremely high temperatures necessary to test successfully the nose cone design.

During the *X-17's* flight, which takes little more than six minutes, the missile continuously radios to ground stations vast quantities of information on velocity, acceleration, heat, and other performance.

Components for Jets and Guided Missiles Given Fatigue Tests. A high-intensity noise-system which, for the first time, makes possible quick, economical preflight laboratory tests of the survival capacity of electronic components and assemblies for jet aircraft and guided missiles has been developed by the Radio Corporation of America (RCA).

A. R. Hopkins, general marketing manager, RCA Commercial Electronic Products, said the RCA noise-system is believed to be the first of its kind capable of providing complete, flexible fatigue tests of components over a wide frequency range.

The noise-system simulates in-flight noises up to levels of 145 db and will enable design engineers to predetermine the structures and characteristics which must be designed into critical components to enable them to survive the acoustic vibration induced by supersonic flight environment.

The noise-system is available in two models. One model features a test chamber with dimensions of 36 by 18 by 72 inches. The second model, for testing smaller components and assemblies, provides a chamber size of 9 by 9 by 24 inches. The system can be assembled with a range of chamber sizes to meet customer requirements.

Inasmuch as the fatigue of components and circuitry represents an increasingly serious design problem in the jet aircraft field where equipment is exposed to the rigors of high-intensity noise fields, the newly developed noise system will permit realistic fatigue tests of components still in an early design stage, will provide quick determination of noise conditions which cause specific equipment failure or malfunction, and will minimize the need for costly operation of jet engines to perform environmental testing of components to meet both military and commercial aircraft requirements.

Basic components of the system include specially designed low-frequency and high-frequency transducers, used as sound reproducers to produce the required spectral response; a new-type sound generator, which produces "white noise"; filters, to pass only those signals within the desired frequency range; equalizers, to provide proper distribution of sound energy; amplifiers, to drive the transducers; and crossover networks, to divide electrical signals properly among the low-frequency (below 600 cycles) and high-frequency (above 600 cycles) transducers and drivers.

Classification and Pay Schedule for Engineers

A separate classification and pay schedule for engineers employed by the Federal Government has been recommended to a U. S. Senate subcommittee in testimony by the National Society of Professional Engineers (NSPE).

The NSPE testimony emphasized that "an adjustment of the salaries of engineers and scientists in the Federal service is in order and is required if the Government is not to fall further behind in its effort to obtain and retain competent engineering staffs."

Testifying before the Subcommittee on Federal Employees Compensation, Senate Committee on Post Office and Civil Service, P. H. Robbins, executive director of the NSPE has urged the passage of a bill (*S.1326*) sponsored by Senator O. D. Johnston (Dem., S.C.), civil service committee chairman, which would assign engineers and other professionals to separate schedules and classifications systems.

Mr. Robbins cited the difficulties experienced by Federal agencies in securing and retaining the services of scientists and engineers, and pointed out that an NSPE salary survey for 1956 indicated that engineers in the Federal service were paid at a rate 21% lower than in private industry.

The NSPE representative also testified that "attempts to eliminate the discrepancy between Federal salaries and those in private industry will not afford a complete, long-lasting solution to the need for engineers and scientists in the Federal service."

"In addition to immediate or long-range salary increases, the Federal Government must afford the scientists and engineers professional recognition," the testimony continued.

The NSPE testimony challenged one of the conclusions made by the recent Cordiner Committee study which found that a separate pay schedule for professionals would violate sound principles of salary administration.

"We suggest that the Government cannot have it both ways," Mr. Robbins said, "that professional skills are an indispensable element, the lack of which imperils our nation's security and progress, and at the same time insist that this same group be treated in the same manner and under the same conditions as general employees in other categories."

The NSPE testimony also carried the recommendation that "to assure that the engineers in Federal service are fully qualified for their positions by reason of education, training, and experience, we believe their competence should be certified by qualifying as professional engineers as established by law in all the states, territories, possessions, and the District of Columbia."

"The National Society of Professional Engineers believes that where a professional field is clearly delineated by law, the Federal Government should accept and follow the line of demarcation between those who are legally qualified to practice the profession and those who are not so qualified."

Mr. Robbins proposed "the institution of a registration requirement for new employees or promoted employees to engineering positions at the level of Federal classifications which would require as a prerequisite approximately four years of broad and progressive professional engineering experience."

He suggested that the point at which registration as a professional engineer would be required, should be the proposed SPS-5 ($8,710-$9,610).

The NPSE representative pointed out that a law requiring registration for other professions is not unique. "The Federal Government for many years has insisted on state licensure as a requirement for certain doctors, nurses, and lawyers in the Federal service," Mr. Robbins said.

Light Rays Set Camera Lens

Energy from solar or light rays has been harnessed to set the lens of a new automatic 8-mm movie camera introduced by the Bell & Howell Company.

This is said to be the first camera in the world in which light energy alone supplies the power to generate the electric current that adjusts the lens. No batteries, motors, or springs are used for the exposure setting. The current is transmitted directly from the photoelectric cell to a mechanism controlling the iris of the lens.

It is also the world's first completely automatic movie camera in the 8-mm size. The movie maker winds the camera, sights, and shoots. The electric eye, which adjusts to changing light faster than the human eye, sets the lens for proper exposure before the starting button is touched. It can operate the lens through its full range of stops in less than one second.

No focusing is necessary, and the camera

Future Meetings of Other Societies

NACE, North Regional Meeting and Symposium, Oct 1-4, Sherman Hotel, Chicago, Ill. A. B. Campbell, NACE, 1061 M & M Bldg., Houston 2, Texas

AIME (contact Headquarters, 29 W. 39 St., New York, N.Y.)

Society of Petroleum Engineers, Fall Meeting, Oct 6-9, Adolphus, Baker, and Statler-Hilton Hotels, Dallas, Texas

Society of Mining Engineers, Annual Meeting and Southeastern States Mining Conference, Oct 15-18, Hillsboro and Tampa Terrace Hotels, Tampa, Fla.

Southern California Petroleum Section, Fall Meeting, Oct 17-18, Biltmore Hotel, Los Angeles, Calif.

The Metallurgical Society, Institute of Metals Division, Fall Meeting, Nov 4-7, Morrison Hotel, Chicago, Ill.

Electrochemical Society, Oct 6-10, Buffalo, N.Y. Dr. H. B. Linford, 216 W. 102 St., New York, N.Y.

SMPTE, 82nd Convention, Oct 6-11, Hotel Statler, New York, N.Y. SMPTE, 55 W. 42 St., New York, N.Y.

Armour Research Foundation, 10 W. 35 St., Chicago, Ill.

National Noise Abatement Symposium, 6 cosponsor organizations, Oct 10-11, Hotel Sherman, Chicago, Ill.

Computer Applications Symposium, Oct 23-24, Hotel Sherman, Chicago, Ill.

ASCE, Convention, Oct 14-18, Hotel Statler, New York, N.Y. Don Reynolds, 33 W. 39 St., New York, N.Y.

Institute of Radio Engineers

Canadian Convention, Oct 16-18, Toronto, Ont., Canada. G. Sinclair, 70 Sheffield St., North Park P.O., Ont., Canada

East Coast Aeronautical & Navigation Conference, Oct 28-30, Lord Baltimore Hotel and 7th Regiment Armory, Baltimore, Md. H. Schutz, The Glenn L. Martin Co., Baltimore, Md.

1957 Electron Devices Meeting, Oct. 31-Nov 1 Shoreham Hotel, Washington, D.C. Dr. W. M. Webster, RCA Tube Div., Harrison, N.J.

4th Annual Meeting on Nuclear Science, Oct 31-Nov 1, Henry Hudson Hotel, New York, N.Y. W. A. Higinbotham, Brookhaven National Laboratories, Upton, N.Y.

Society of Plastics Engineers, Inc., Technical Conference, Oct 17, Hotel Carter, Cleveland, Ohio. E. J. Haskins, Zenith Plastics Co., 1009 Rockwell Ave., Cleveland 14, Ohio.

ASME, Power Conference, Oct 21-23, Americus Hotel, Allentown, Pa. L. S. Dennegar, ASME, 29 W. 39 St., New York, N.Y.

National Academy of Sciences—National Research Council, Conference on Electrical Insulation, Oct 21-23, Pocono Manor, Pocono Manor, Pa. Mrs. M. F. Boswell, NAS–NRC, 2101 Constitution Ave., Washington 25, D.C.

National Safety Council, 45th National Safety Congress & Exposition, Oct 21-25, Conrad Hilton Hotel, Chicago, Ill. R. L. Forney, NSC, 425 N. Michigan Ave., Chicago, Ill.

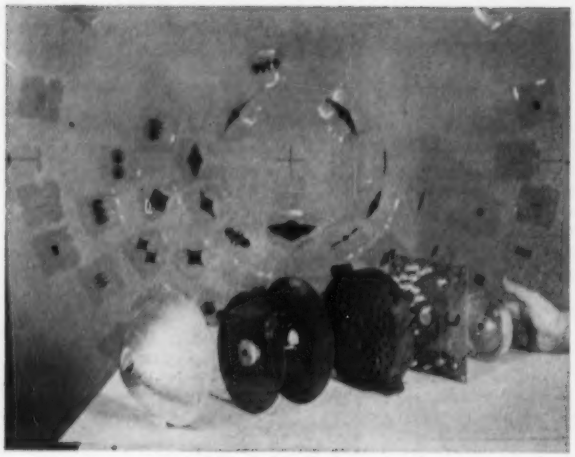
AIChE, 1957 All-Day Symposium, Oct 22, Hotel Statler, New York, N.Y. T. P. Forbath, AIChE, 330 W. 42 St., New York, N.Y.

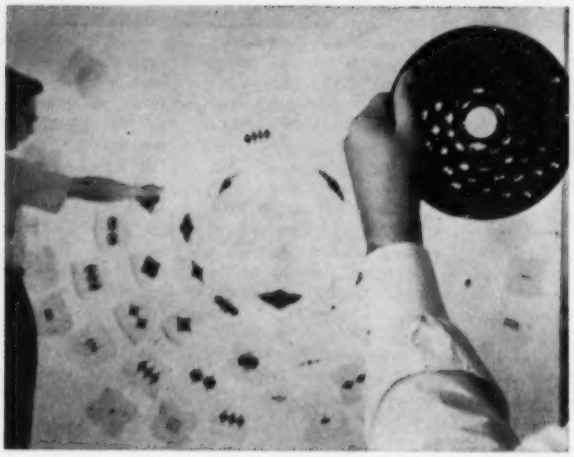
Aircraft Electrical Society, Exhibition, Oct 24-25, Pan Pacific Auditorium, Los Angeles, Calif. Lynn-Western, Inc., 6901 Melrose Ave., Los Angeles, Calif.

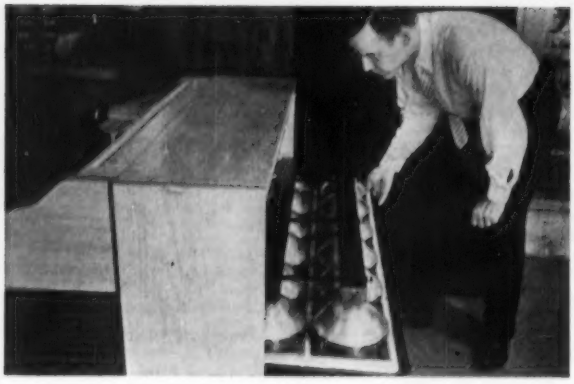
Atomic Industrial Forum & the American Nuclear Society, Conference on Management, Economics, and Technology, Oct 28-30, New York Coliseum, New York, N.Y. AIF, 3 E. 54 St., New York, N.Y.

American Nuclear Society, 2nd Winter Meeting and 3rd Trade Fair of the Atomic Industry, Oct 28-31, Henry Hudson Hotel, New York, N.Y. John Burt, J. M. Mathes, Inc., 260 Madison Ave., New York, N.Y.

National Council of State Boards of Engineering Examiners, 36th Annual Meeting, Oct 31-Nov 2, Atlanta (Ga.) Biltmore Hotel. Col. M. E. Cox, Atlanta, Ga.







WORLD-FAMOUS ORGANS will supply the notes which will be played on the electric organ shown at left. Back has been opened to show generating units which are enclosed in rear of instrument. In the picture above left is an exploded view of one of the generating units comprised of the light bulbs, scanning disc, impulse relay piece, and waveshapes of individual notes on disc seen third from left. Picture above right shows individual notes waveshape disc in foreground with projection on wall showing magnified waveshapes for comparison purposes.

can be used with indoor as well as outdoor color film. Without knowing what an *f*/stop is, the movie novice can now be sure of properly exposed film every time, a result not consistently achieved by the experts. Any subject at all can be followed from light to shadow because the electric eye accurately computes the light changes and automatically adjusts the lens to compensate for any change. With a conventional camera, shooting would have to be interrupted in order to change the exposure setting each time.

To make feasible the design approach of the electric eye, engineers developed a new type of lens iris so sensitive that it moves at the touch of a human hair. However, it is sturdy and shockproof, and it has withstood the most vigorous environmental and field tests.

Through the use of thermistors, the electric eye mechanism adjusts to temperature changes. The camera can be used at any temperature extremes the film itself will withstand.

Light reflected from the subject enters a reticular honeycomb lens which controls the angular coverage to match that of the camera lens. Upon reaching the photocell, the light generates an electric current which is fed to the meter mechanism. The meter computes the correct exposure and opens or closes the lens as required.

Linked to the control mechanism is a needle pointer which moves back and forth along a visible scale, indicating the opening at which the lens is set. The scale is marked in *f*/stops of 1.9, 2.8, 4, 5.6, 8, 11 and 16.

The camera can also be operated manually. Turning a dial from "auto" to "manual" disconnects the automatic exposure control so that the lens may be set for under- or overexposure in order to obtain special effects. When the camera is operated manually the needle pointer indicates the opening at which the lens is manually set without regard to the correct exposure.

Electric Organ with World-Famous Pipe Organ Sounds

An electric organ for homes and churches which reproduces identical sounds taken from world famous pipe organs has been introduced.

The instrument, about the size of the average spinet piano, has a full pipe organ keyboard, is played exactly the same way, and produces notes and tones selected from several of the world's most outstanding pipe organs through a "sound picture" and optical lens process.

W. W. Kimball, president of the piano and organ company which bears his name and which is 100 years old this year, says this organ cannot get out of tune. It will be competitively priced with other electric organs made for home use.

The mechanism of the new organ, according to the development engineers, is basically simple.

When you press any key of the organ, a small peanut-sized bulb lights within its own cell in one of the 12 generating units. The bulb casts a small, straight light beam through a special lens with an opening shaped to form the note called for. The light passes through this lens onto a revolving scanning disc, which acts as part of the "central nervous system" of the organ. This scanning disc, depending on the note selected, relays the light beam on to a specific part of a photoelectric cell which produces the identical sound desired, through a high fidelity amplifier and speaker—much the same way high fidelity sound is produced with motion pictures.

Most of the playing mechanism is contained in the generating units (each about 9 inches in diameter), installed in the back section of the organ. To repair any part of the unit, the back is simply let down like a folding table. Any average homeowner, radio, or television repairman can make normal repairs, the manufacturer states—an important advantage during this period when electric organ specialists are scarce.

The original development engineer to work on the new organ, Mertin Petroff, worked on the theory that each sound produces its own "picture" when viewed

on an oscilloscope (an instrument for studying sound characteristics). He reasoned that if a "picture" could be produced for every stop in an organ, and if that picture could be relayed to photoelectric cells, identical pipe organ sounds could be produced by pressing the keys.

To perfect the Petroff theory, the Gibbs Manufacturing and Research Corp., development engineers of Janesville, Wis., famous for their work in developing electronic phases of guided missiles and pilotless aircraft were retained. Gibbs discovered that the sound "picture" seen on an oscilloscope does not relay the perfect message to the photoelectric cell. Through integral calculus, they determined the proper picture for each sound heard from a full keyboard pipe organ. They then transferred each picture (a picture for each note) to a lens, thus overcoming the biggest hurdle encountered in the development.

There are comparatively few pipe organs which are recognized as great by experts in the music world. Of these, each is noted for special tone qualities. The company is endeavoring to obtain the best sounds of the best pipe organs, and transferring them to tone pictures which go into the new organs.

Automatic Fine Tuning

Correct fine tuning of today's television set can be accomplished only when (1) the sound carrier signal is about 30 db below the picture carrier signal at the video detector, and (2) the picture carrier signal is about one half the peak i-f response. The first requirement insures good sound quality without false picture distortion; the second assures good picture detail and eliminates highlights in dark areas. Electronic circuitry developed by Westinghouse Electric Corporation television engineers provides automatic fine tuning by maintaining these two essential requirements simultaneously under such adverse receiving conditions as drift, tilt, and fringe tuning.

Before the advent of electronic automatic fine tuning, an automatic gain control circuit maintained the picture carrier level at a constant value selected by the viewer. The new electronic fine tuning circuitry measures the picture carrier level and the sound carrier level, and operates to maintain the picture–sound carrier ratio at the proper value by controlling local oscillator frequency. The operation of automatic fine tuning can be demonstrated for drift, tilt, and fringe tuning on the intermediate-frequency passband curve.

Drift—If the local oscillator drifts and thereby moves the picture carrier and sound, automatic fine tuning automatically controls the local oscillator to return the sound and picture, thereby maintaining the correct picture–sound carrier ratio and good picture quality.

Tilt—A certain amount of tilt is often introduced into the over-all passband. This can be caused by attenuation and reflection effects of terrain, receiver antennas, or antenna lead-in connections. Attenuation or cancellation will vary over the frequency range, resulting in the "tilted" passband. Hence, a local oscillator operating at the correct frequency for the normal flat passband would produce a considerably distorted picture–sound ratio on the tilted passband. Automatic fine tuning automatically detects this distortion and corrects it, to restore the proper sound–picture ratio.

Fringe Signal Response—In fringe areas, the signal is relatively weak and, consequently, the signal-to-noise ratio poor. Because a sharp picture is impossible under these conditions, picture sharpness can be sacrificed in favor of maximum picture–signal gain by moving the picture carrier frequency to a position of higher response. The automatic fine tuning receiver i-f passband is altered for fringe-station reception. This alteration is accomplished by means of a "programming wheel." This wheel permits the customer to select either a fringe or local type performance for each channel in his area, in addition to the normal programming function of causing the station selector to stop on or skip a channel. When the small nylon slidder is in the external position, the channel selector will stop on that station with the automatic fine tuning set for correct local station reception. If the slidder is pushed in one notch, the channel selector will stop on that station, but with the automatic fine tuning set for correct fringe area reception, the local oscillator automatically moves picture and sound. This can be done on the conventional i-f passband by manually tuning in the same direction, but automatic fine tuning gives the advantage of automatically maintaining proper picture–sound carrier ratio while in the fringe position.

Gas Turbine Unit in CAA *440* for Special Needs

A unique installation of an AiResearch gas turbine unit is being made aboard a Civil Aeronautics Administration (CAA) Convair *440* to provide power for operation of special electronic and electric monitoring equipment in its cabin.

CAA plans are to use the *440* to flight check radio navigational and communications facilities throughout the United States, while flying at altitudes from 10,000 to 20,000 feet.

This is the first CAA-approved installation of a gas turbine power unit.

The Garrett Corporation's AiResearch Aviation Service Division, Los Angeles, (Calif.) International Airport, is installing the unit, model *GTP70-10*, which is equipped with a 40-kva alternator to produce twice the plane's normal maximum electrical output.

Specifications require that the power unit be isolated from the cabin atmosphere, thus it is being housed in an airtight, soundproof capsule. This capsule, and the air intake and turbine exhaust systems are designed and fabricated of stainless steel by AiResearch Aviation.

Fuel for the power unit is provided from the aircraft system.

The turbine enclosure and mounting are designed for quick disconnect and removal. A complete fire detection and suppression system is incorporated in the installation.

An unusual feature of the setup is that a portion of the alternator's output can be changed to direct current by directing it through four 100-ampere transformer-rectifier units. This can be used for starting and ground checkout of the aircraft. It can also be made available for operation of a portion of the ship's electrical system in an emergency.

Also to be installed is a two-screen radar system in the CAA *440*. One viewplate is in the pilot's center instrument panel and the other at the operator's position in the cabin. To house the antenna, a radome was fabricated and fitted on in replacement of the *440's* standard nose.

Urge Retention of ISM Frequencies

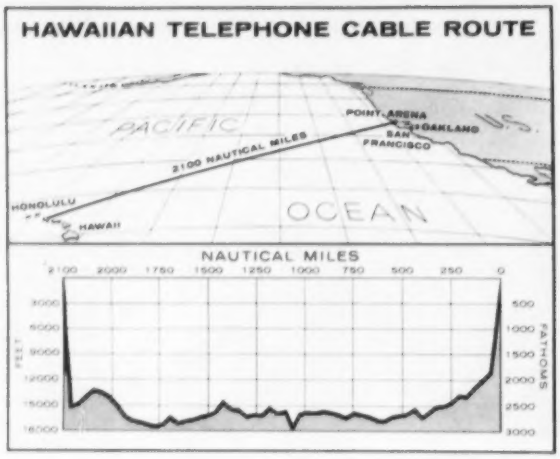
In recent testimony before the Federal Communications Commission (FCC) in Washington, D. C., Raytheon Manufacturing Company officials urged continuance of the principle of assigning frequency bands in which ISM (industrial, scientific, and medical) equipment is permitted unlimited radiation.

Dr. I. A. Getting, vice-president, engineering and research, testified that Raytheon was a pioneer in both the microwave tube and microwave equipment field, and urged that present frequency allocations be maintained. Recommendation also was made for moderate increases in total bandwidth involving microwave energy associated with such products as the company's electronic ovens and medical diathermy units. In addition, it was recommended that the present maritime radar and navigational beacon frequency allocations be continued; and, that two additional maritime radar bands, with associated navigational beacons necessary, be allocated.

Dr. Getting went on record as declaring that microwave energy will perform feats in the industrial, scientific, and medical fields which either cannot be performed at all or cannot be performed as effectively by other means. Microwave energy, he said, is unique in that it will generate heat evenly throughout the entire mass of an object, whereas conventional heating methods will not do this.

ISM applications differ from communications uses in that radio frequencies are employed to generate heat or energy rather than to convey intelligence. The following special problems arise as a result: (1) installations such as these can be very numerous, (2) in general there will be radiation in the band, and (3) the locations of such radiating sources cannot be controlled geographically.

In summary, Dr. Getting indicated that a multiplicity of ISM bands is required



HAWAIIAN submarine telephone cable system reaches from Point Arena, Calif., to Honolulu, Oahu, T.H. Lower sketch shows varying depths of Pacific Ocean floor over which cable was laid.

to provide for the public welfare and economic growth in the ISM fields.

Additional testimony was offered by D. R. Hull, vice-president and general manager of Raytheon's equipment operations, who went on to say that only within recent years has electronic cooking been accepted as a useful and, in certain cases, a necessary cooking technique. It was also emphasized that after 10 years in this field, the company felt that the 2,400- to 2,500-mc bandwidth is the best frequency for microwave cooking purposes. The advantages of electronic cooking were cited. Of particular interest to the FCC was the statement that a group of California hospitals has reported savings of about 10% in raw food costs alone, and total savings in food and labor of approximately 8¢ per meal served by the use of a hospital feeding system designed around microwave ovens.

Testimony given was put into the record backing up the company's use of the 2,400- to 2,500-mc band in both cooking and medical diathermy. It was stated that the importance of microwave diathermy equipment could not be measured in terms of dollars only. Of greater significance are the therapeutic benefits and relief from pain and suffering which the American public enjoys from its use. The statement of the American Medical Association (AMA) previously submitted in the hearing, that "thousands of American physicians today use microwave diathermy apparatus which operated on the frequency of 2,450 mc. Substantial therapeutic benefits would be denied patients if allocation of this frequency band is not continued within the ISM use category. The Commission is therefore urged to retain assignment of this frequency band to the ISM category." This extensive use by physicians of microwave diathermy equipment testifies to the value of the 2,450-mc frequency for medical purposes was a point brought to the attention of the members of the FCC.

It was predicted that frequencies in the 5,800-mc range and above will someday be utilized industrially for surface drying, and for the curing of plastics, paper, and other thin materials in specialized metallurgical and other processing techniques.

It was concluded that all three of the present maritime radar and navigational bands were being utilized for marine radar—commercial and Navy equipment in the 3,000- and 9,320-mc bands and Navy equipment in the *C* band.

Supporting statements favoring the two additional maritime radar bands, with associated navigational beacons, were offered by I. L. McNally, also of Raytheon, who stated that a positive means of identification of vessels is required. Also, that the two additional bands in the higher frequency ranges are desirable for the development and application of high resolution radar for harbor traffic control and river navigation purposes, and that beacons are required for positive identification of vessels within radar range.

He also indicated that the full possibilities of beacons, both active and transponder, have not been exploited. Simple crystal video receivers, with small directional antennas, have been proved effective for homing on radars and active beacons.

Mr. McNally concluded that "this request for a maritime radar band allocation above the 30,000-mc range should be co-ordinated with the requirements for radio astronomy in this same frequency region. It can be expected that favorable action on the two additional recommended bands will stimulate increased development effort to meet the special demands of harbors and inland waterways."

Before the hearing was over, Dr. Getting made a final appearance, calling the FCC's attention to the company's activities in the recently revealed freeze-dry technique of food preservation which has stirred great interest throughout the entire country—a process in which solid materials, in this case food, are frozen and then dehydrated under deep-freeze conditions. Actual samples of food dehydrated in the frozen condition under vacuum by the use of microwave energy in the 2,450-mc ISM band were shown. In these foods over 95% of the moisture had been removed. Inasmuch as enzyme and bacteriological action cannot take place in the absence of adequate moisture, it was stated that these foods were thereby preserved for an indefinite time for storage at room temperature.

Twin Telephone Cables Link Hawaii to Mainland

The cableship *Monarch*, grey hulled veteran of scores of deep-water ventures, was on her biggest assignment—laying of the first undersea telephone link with Hawaii.

Monarch, her four cable tanks brimming with some 1,900 miles of armored cable, has the leading role in a multiship laying operation.

The vessel sailed for a spot 10 miles off Point Arena, Calif., site of the eastern terminus of the underwater twin cable system. According to the long lines department of American Telephone and Telegraph Company (AT&T)—Bell System unit in charge of the cable laying—the cableship would pick up the end of a shore section placed there earlier this year, splice it to the cable in her tanks and head for the Islands. *Monarch* will be paying out cable at approximately six knots as she steams along on her southwesterly course.

Both of the 2,400-mile cables for the new Pacific voiceway will be capable of carrying 36 simultaneous conversations. Featuring the dialing of calls between the mainland and Hawaii service is expected later in the year, climaxing three years' planning and construction by AT&T, the Hawaiian Telephone Company, and The Pacific Telephone and Telegraph Company, participants in the project.

Two other vessels were engaged in the precisely timed, summer-long cable laying operations. They were the cable-laying *Ocean Layer*, and the cable supply ship, *Arthur M. Huddell*. AT&T said there would be virtually no interruption in round-trip cable operations between the mainland and the Hawaiian Islands. Laying was done in the following sequence: (1) from Point Arena westward, *Monarch* laid the first 1,900 miles and buoyed the cable end before proceeding to Honolulu; (2) *Ocean Layer* rendezvoused with *Monarch* at the buoy, took the cable end on board, made a splice, and continued another 665 miles to the entrance of Hanauma Bay, on the Island of Oahu, where, the east–west cable was joined with one of the newly laid Hawaiian shore sections; and (3) both cableships were then reloaded with cable from the *Huddell* at Honolulu.

For the second cable (west to east), *Ocean Layer* picked up the second Hawaiian shore section and laid some 800 miles eastward and buoyed the end. *Monarch* picked up the cable end and continued to Point Arena for the final mainland splice.

It was pointed out that the compatibility between mainland and Hawaiian telephone facilities would enable an operator in Honolulu to dial direct to any number in the estimated 6,500 communities on the mainland. In like manner, mainland operators in hundreds of cities can dial any subscriber on the island of Oahu, where 95% of Hawaii telephones are located. This will be the first of AT&T's ocean cable systems to be equipped for operator dialing.

The Hawaiian cable system is similar

in design and construction to the 2,250-mile Atlantic telephone cables extending between Newfoundland and Scotland, and the 900-mile Alaskan cables between Port Angeles, Wash., and Ketchikan, Alaska—both opened to service in 1956. The trans-atlantic cable system was the first deep-water voice link to cross an ocean.

The Hawaiian cables will generally be in deeper water than either the Alaskan or Atlantic cables. At one point, they will strike a depth of about three miles.

Cables are of the coaxial type, especially designed to withstand the tremendous pressures of the ocean bottom. And sturdy, flexible repeaters are built into the cable about every 40 miles to boost the strength of signals when they reach the fading point along their deep-sea course.

The Hawaiian cables will substantially augment the 14 radio circuits presently operating between these points.

Four Languages Interpreted by Computer

An electronic computer has been programmed to interpret four foreign languages and then to type out automatically the idiomatic English translations of the texts fed to it.

Peter Toma, 32-year-old Hungarian technician at the California Institute of Technology, fed a Datatron electronic computer four excerpts in Russian, French, German, and Spanish. One was a headline from the Soviet newspaper *Pravda—"Mashina perevodit s odnovo yazeeka na drugoy."*

Datatron flashed its neon lights and printed on an electric typewriter the precise English equivalent: "Machine translates from one language into another."

According to Mr. Toma, this marks the first real breakthrough toward a universal interpretation of all the world's tongues—and a common written language. His is the only technique which has been formulated for multiple-language machine translation.

Datatron does not merely produce a word-for-word record, but correctly renders the thought or "sense" behind each foreign phrase.

Mr. Toma's semantic-unit formula is entirely new, and "opens the way to the use of machine-translation in international diplomacy and cultural exchanges," it was stated at the unveiling.

To prime his electronic linguist, Mr. Toma first transmitted to its magnetic memory drum four specially condensed dictionaries of Russian, French, German, and Spanish. These had been punched on paper tape in numerical computer language, along with instructions telling Datatron how it should go about translating.

The computer—which adds or subtracts at the rate of 30,000 numbers a minute—electronically converted the code into alphabetic characters, and compared various semantic and logical patterns with the pre-stored glossaries. In several minutes, the machine had typed out a page of English translation idiomatically.

Toma's dictionaries comprise about 500 words each. They can be easily retained on Datatron's high-speed internal memory drum, with a capacity for 40,800 digits.

For future enlargement of these dictionaries, plans are to use ElectroData's new multiple magnetic tape unit called Datafile. Ten of these external memories, housed in "deep freeze" cabinets and linked to Datatron, can store 200 million characters of information—any one retrievable in seconds.

Both magnetic drum and tape record lingual data in the form of scattered magnetic spots, scanned by electronic reading or writing heads.

Front-Line Combat Surveillance from Drone Aircraft

Electronics has again come to the aid of front-line soldiers in the form of a new television "strip camera" now being perfected which is a logical development in a series of projects for the Army's Combat Surveillance Department. Combat Surveillance is intended to fill the gap between front-line patrol activity, a dangerous and often haphazard way to get information.

An Army general wants the big picture; he needs to know where the enemy is massing his troops, storing his material, building his airfields.

The front-line commander, on the other hand, needs details. Ideally, he wants the location of every enemy soldier, every tank, every gun emplacement in front of his lines. To give the combat commander effective intelligence tools, the Combat Surveillance Department of the U.S. Signal Corps has been organized, with proving grounds at Fort Huachuca, Ariz.

Inasmuch as the new intelligence techniques to be developed are intended to represent the most advanced concepts in electronics, optics, and systems design, Hycon Manufacturing Company of Pasadena, Calif., has contracted to carry out a number of the Fort Huachuca projects. Over 24 separate programs have been or are being worked on.

Typical of these is the successful development for the Signal Corps of a lightweight camera, the *KA-20*, for drone aircraft. The *KA-20* was specifically designed for maintenance and operation by comparatively untrained combat troops. Close support photography by drone aircraft is particularly advantageous in front-line reconnaisance since the photographic detail required by front-line commanders requires low-level flight by the reconnaissance craft. A drone is small, fast and difficult to hit; it can operate over heavy enemy troop concentrations without risking a pilot's life; and, most important, it can be launched and recovered from any sort of terrain.

The Hycon *KA-20* drone camera not only had to be lightweight and rugged (it has to withstand a 15-G shock when the drone is recovered by parachute), but also easy to operate and maintain. Vacuum is required for example, to hold the film in place, and engineers used the simple expedient of mounting Venturi tubes on the drone fuselage surface to provide a vacuum source. Preset altitude settings automatically adjust the IMC (image motion compensation) mechanism that moves the film, during exposure, to compensate for the speed of the low-flying plane.

The original goal was to develop a camera weighing 30 pounds; the final configuration of the *KA-20* weighs only 17½ pounds. Resulting photographs are 9 by 9 inches without enlargement, giving the viewer a detailed picture of the ground. Contact prints can be made easily and quickly in the field.

An adaptation for the *KA-20* camera permits night surveillance of combat areas. In this case, the camera shutter remains open, while an associated piece of equipment automatically ejects a series of flash cartridges. As each cartridge explodes, briefly illuminating the ground below and a picture taken, a photo-electric cell on the camera detects the reflection of the flash from the ground and automatically advances the film for the next exposure. The Hycon-developed ejector pod has a capacity for 26 flash cartridges, each of which can develop 110 million candlepower in 1/300 of a second Safety devices have been incorporated so that the flash cartridges cannot be ejected accidentally before the plane or drone leaves the ground.

Under certain conditions, airborne radar can also be used to gather ground intelligence, and a number of Hycon projects have been devoted to adapting radar equipment for service in light reconnaissance planes.

The objective in every case is to provide the battlefield commander with an intimate, almost instantaneous picture of his tactical situation. Armed with this information, he can send his troops with a minimum of casualties into areas of temporary weakness, and can shift his own forces to meet assaults at the first indication of enemy action.

U.S. Army Signal Corps Photo

KA-20 reconnaissance photography provides excellent information for the general staff in a fast moving front-line situation. Picture above was taken from plane silhouetted at center right.

Major Advance in Electronics Simplifies Design

Dependable world-wide communications are now well on the way with the advent of a new type of radio and radar component. The device, called a high frequency crystal filter, makes it possible for more radio stations to transmit without overlapping and interfering with each other. At the same time, the new device greatly simplifies electronic equipment. High frequency crystal filters are to existing conventional filters what transistors are to vacuum tubes.

Mass-produced high frequency crystal filters represent a major breakthrough in the communications art. Now that crystal filters are commercially available, military and industrial designers have already started to work on new designs which will provide significantly better communications and navigation equipment.

Simpler radio and radar receivers will result from the inclusion of crystal filters where tuning and alignment are not necessary. A technique known as multiple conversion has been used for years to get around certain filtering problems. Using a crystal filter in the circuit, multiple conversion becomes unnecessary. The result is a radio or radar receiver with fewer parts. The higher the frequency of the receiver (which are the present trend), the more applicable this simplification becomes.

Primary applications of the highly reliable crystal filters will be in the field of mobile communication equipment such as military vehicular radios, walkie-talkies, taxicab and industrial radios; military communications and navigation equipment in ships and airplanes; intercontinental radio systems, such as over-the-horizon scatter links; telephone systems; radar systems; and missile systems. Many other varied applications for crystal filters and associated devices are also foreseen, including a tiny button microphone which can be worn on the lapel and which will transmit messages or speeches several hundred yards without any connecting power sources. These same quartz crystal devices will make it easier to generate frequency-modulated signals for noise-free communication (better FM stations). Sources of other uses are forecast by electronic specialists who hail the new low-cost filters as one of the more important technological advances of this decade.

Frequency Standard Calibration Device Developed

A compact, improved "Frequency Standard," the first airborne equipment of its kind, has been developed for the Air Force's Air Research and Development Command (ARDC).

Used to calibrate all airborne electronic equipment that depend upon frequency accuracy—such as radios, radar, navigation, fire control, and timing devices—the Frequency Standard has passed acceptance tests at ARDC's Wright Air Development Center (WADC), Dayton, Ohio. With a fine-line accuracy never before achieved in such a small device, it is unaffected by temperature extremes and has successfully withstood rigid Air Force vibration tests.

Developed as a "one-package," or self-contained unit by The G. W. Borg Corporation, it weighs only 30 pounds and measures only one-half cubic foot, including a battery that can operate the "Standard" for 2½ hours. The Standard's output is a 100 kc signal. The maximum error or deviation from this signal is one part in 1 billion per 6 hours during operation in temperature extremes or while being vibrated. It uses a single crystal oscillator to establish the frequency signal.

A typical conventional Frequency Standard able to achieve this accuracy would measure about 2 cubic feet, would weigh 80 pounds, and would be composed of two or more units. This type of Standard could be used only under ideal conditions or in a laboratory.

All airborne electronic equipment which requires signal transmission and reception must be calibrated frequently. Present practice is to calibrate this equipment with a ground unit before take-off. The new Frequency Standard, designated *O (XA-31)/U*, will permit airborne calibration continuously if necessary. It can also be used on the ground at radio or radar sites, or in laboratories.

The Standard has successfully met the requirements of stringent tests. It has undergone temperature extremes from —55 C to +70 C, has operated at 50,000 feet altitude, and has received severe vibration tests—including drop tests.

Ease of maintenance has been increased by building the Standard so that the various circuits and components may be replaced by "plug-in" counterparts. Development was begun 2½ years ago.

The Standard uses the conventional aircraft power system of 28 volts d-c, or 110 volts 400 cycles per second, draws an average power of only 25 watts, and can be used in any type aircraft.

Standardization of Automatic Controls Terminology

The increased use of automatic controls in manufacturing industries, in process industries, and in business administration has brought about a need for creating a common language for this field of engineering effort. Under the auspices of the American Standards Association, a project has been started to establish standard terms pertaining to automatic control, and to develop definitions of such terms.

To handle this project, Sectional Committee C-85 has been constituted under ASA procedure, and its organization has been approved by ASA as of April 5, 1955. Its title is "Terminology for Automatic Controls." Its sponsor is the American Society of Mechanical Engineers. Its scope is as follows:

> "Terminology pertaining to systems such as: automatic process control, feedback control, regulating and other related systems not requiring human intervention as part of the regulating procedure."

Committee officers are:

Chairman: M. A. Princi, General Electric Company, Lynn, Massachusetts.

Secretary: G. W. Heumann, General Electric Company, Schenectady, New York.

C-85 is charged with the responsibility of establishing standard terms and defining them. Therefore, the document which C-85 is developing will be a dictionary of terms and definitions. In this work, a close relationship is being maintained with Sectional Committee Y-10, also under the auspices of ASA which has been assigned the responsibility for letter symbols and graphical representations as used in automatic control systems.

A review of source material published in the United States brought to light over one hundred items of published standards, draft of standards, papers and articles dealing with terminology for automatic control systems. Among these sources are:

> "Automatic Control Terminology" published 1954 by ASME, "Letter Symbols for Feedback Control Systems," tentative draft of ASA Sectional Committee Y-10.14 published 1955, "IRE Standards on Terminology for Feedback Control Systems, 1955."
>
> "Accuracy and Sensitivity Terminology as Applied to Industrial Instruments" prepared tentative standard, published 1955, by SAMA.
>
> "Proposed Symbols and Terms for Feedback Control Systems" published 1952, by the AIEE Feedback Control Committee.

In the foreign field, standards on automatic control terminology have been issued by Great Britain, the Netherlands, and West Germany. A Technical Committee of the International Electrotechnical Commission is working on a glossary of automatic control terms, but no published document is available as yet.

As an initial step in organizing its work, C-85 has set up several subcommittees, each being assigned a certain work area which will be covered in the initial document which C-85 plans to publish. The subcommittees and their work areas are as follows:

> Subcommittee No. 1 "Types and Components," Chairman H. A. Miller, Raytheon Manufacturing Company, Waltham, Massachusetts. The committee is working on definitions to describe the basic types of automatic control systems and the various component elements of each system.
>
> Subcommittee No. 2 "Signals," Chairman D. H. Smith, Bell Telephone Laboratories, New York. This committee is defining the signals and process variables which are present in a generalized feedback control system.
>
> Subcommittee No. 3 "Modes and Parameters," Chairman W. I. Caldwell, Taylor Instrument Companies, Rochester, New York. This committee is working on terms describing automatic control action, and the fixed or adjustable parameters which influence control action.
>
> Subcommittee No. 4 "Behavior and Presentation," Chairman Dr. H. L. Mason, National Bureau of Standards, Washington, D. C. This committee defines terms describing in detail the responses of automatic control systems, and their generalized controlled elements.

A co-ordinating committee under the chairmanship of O. W. Livingston, General Electric Company, Waynesboro, Virginia, has been established to resolve questions of concept, procedure, and style as they affect all subcommittees. It will also serve as an editorial committee to draft the tentative Standard which will contain the definitions developed by the above listed subcommittees.

A number of meetings of the main committee and of the subcommittees have been held, and some 200 terms have been defined tentatively. It is anticipated that these definitions will be distributed for comments in the near future.

Education, Manpower, and Technical Versatility

Because of the growing complexity of modern industry, management more and more is seeking versatility from the engineer, according to W. F. Rockwell Jr., president, Rockwell Manufacturing Company.

All too frequently, the engineer tends to restrict his thinking and interest to the purely engineering aspects of a company. Today he must deal with sales, marketing, cost accounting, public relations, and other departments and sections.

It also should be realized that management people expect the engineer to work with them in the same straightforward way he deals with engineers and engineering problems.

One of the important objectives of the engineer's education and training is clear, logical thinking which makes him all the more valuable for the contribution he can make to the solution of problems in other phases of the company's operations.

In order to serve management properly, it is important that the engineer strive to retain his objectivity, even at the risk of being unpopular or disliked. For, in the long run, he will be respected, which is far more important. More than others in a company, the engineer must be ready to dissent, if the facts as he knows them so dictate. It is not for him to ingratiate himself by readily agreeing. It may be that factors of which the engineer has no knowledge make it desirable to follow a different course. But the engineer should still stick to his evaluation as he knows the facts.

An engineer should continue a certain amount of formal education. But even more important is his informal education—the learning and doing on his own. This includes keeping up with technical and trade magazines and other publications, active membership in important trade and technical societies and associations, and preparation of papers and articles. Versatility is the need above specialty.

Teachers Named for Summer Work in Hughes Labs. Some 19 science and mathematics teachers from 15 high schools in the Los Angeles, Calif., area began full-time jobs as scientists and mathematicians on June 24, 1957, when Hughes Aircraft Company started its second annual summer program to interest more teen-agers in science careers. The teachers worked side by side with Hughes scientists for 10 weeks in the company's research and development laboratories at Culver City. In their work, involving current research in electronics, they made practical use of the textbook theories they teach their classes.

Last year Hughes and officials of the Los Angeles City School District co-operated in a similar project in which 10 high school science teachers worked at Hughes. Participating teachers were paid the equivalent of their teaching salaries by Hughes and the project ended August 30.

Teenagers Win Cash for Study at Hughes Labs. A dozen teenagers from 12 high schools in the greater Los Angeles area were awarded summer-study scholarships by Hughes Aircraft. The 10 boys and 2 girls, all of whom will graduate next year, commenced a unique 10-week research project at the Hughes laboratories. Each received $400 for the work, plus an additional lump-sum cash scholarship of $400 at the end of the project, which is to be used for college studies following graduation.

The group research project on which they worked concerned a major community problem. In addition to research work, the students also heard leading scientists discuss new scientific frontiers and toured the Hughes laboratories and manufacturing areas.

Manpower and Education. J. E. Harrington, executive secretary of the Western Society of Engineers, announced recently that the society will provide local sponsorship in Chicago for a comprehensive conference on the relationship of problems of technical manpower supply and quality to the problems emerging in higher education in engineering and science.

The theme of the meeting will be "Engineering and Scientific Education—Foundation of National Strength." Conference goals are to provide an up-to-date picture of the technical manpower problems and their implications for educational resources, to highlight the unique problems and opportunities in engineering and science higher education and to clarify basic issues as we move into a crucial era in the growth and development of higher education in the United States.

As the furor of another recruiting season, with its keen competition for qualified engineering and science graduates, subsides, perhaps the most impressive evidence—all things considered—of greater understanding of the fact and problems of technical manpower shortages is to be found in the serious and fundamental efforts that are being made to use technologists more effectively, to train and to upgrade men with aptitude and experience but without formal training and, of course, further to integrate engineering and science technicians into the technical manpower team.

The Monsanto Chemical Company, for example, has been teaching product chemistry and history to nonchemists who are filling posts in technical sales departments. Some of these employees are college graduates who may not have had undergraduate courses in chemistry, whereas others have had little or no college training of any kind. Regardless of background, these recruits are put through a course in which detailed consideration is given to raw materials and their sources and availability, the products made from each basic raw material, the specifications applying to each of the chemical products sold, and delivery problems.

The President's Committee on Scientists and Engineers has become keenly interested in the problem of improved utilization and at its March 1957 meeting appointed a Task Force to co-operate with educators and representatives of local engineering organizations to plan local clinics "aimed at determining the most effective ways of making use of America's engineering talent."

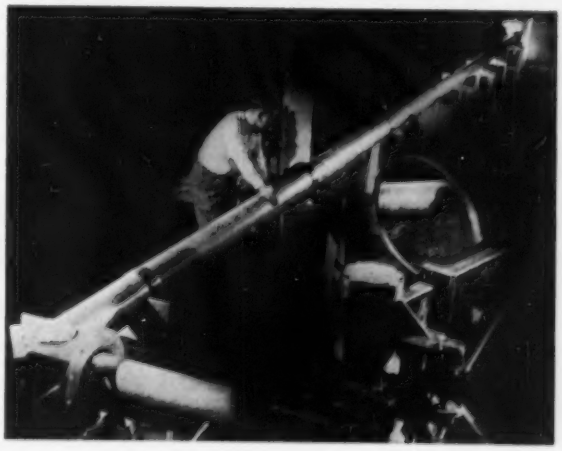
Plans for clinics are already well under way at Rice Institute (Houston, Texas), University of West Virginia (Charleston, W. Va.), and Pennsylvania State University (University Park, Pa.). Task Force thinking is that upcoming conferences should be locally sponsored, bringing together all appropriate organizations and individuals from each area. Sessions will focus on practical programs to improve utilization.

"Hot" Laboratories Use 90-Foot Periscope

What is believed to be the world's longest periscope has been constructed by General Electric Company (GE) engineers and installed at the Atomic Energy Commission's (AEC) National Reactor Testing Station to aid in development work on a nuclear propulsion system for aircraft.

D. R. Shoults, general manager of the Aircraft Nuclear Propulsion Department of GE, said that the 90-foot aluminum tube with an intricate mirror and lens system permits atomic workers to sit safely behind heavy shielding while they watch the performance of a nuclear reactor being tested in the Government's Aircraft Nuclear Propulsion development program.

The 90-foot periscope is operated along with a "little brother" periscope only 60 feet long—almost twice the length of periscopes in use on conventional submarines.



90-FOOT periscope permits engineers to observe "hot" nuclear reactor while in a shielded cubicle. To protect observers from radiation, the "eye" of the periscope, though located only a few feet from the reactor, is pointed away from it at a remotely controlled scanning mirror (*right foreground*). Images are reflected by mirror which can be rotated in any direction.

The two "scopes," developed by the GE General Engineering Laboratory, Schenectady, N. Y., enable observers to watch opposite sides of a reactor while it is operating and thus radioactively "hot."

Motor-driven scanning mirrors located less than a dozen feet from the powerful source of radiation inside the reactor transmit images to observers at the safe ends of the periscopes.

A small control console located beside the observer enables him to swing or tilt the scanning mirrors in any direction to be able to view the reactor from any angle.

A third periscope developed by the laboratory is equipped with a built-in camera and designed for high magnification. With it, hot-cell technicians perform parts-assembly and disassembly jobs which may be compared in delicacy to threading a needle by remote control while using a mirror instead of direct vision.

The two periscopes used for reactor observations bend the viewer's line of sight around three right-angle corners and "bounce it" off the mobile scanning mirrors. Still, because of built-in magnification, the images actually seen through the "scopes" are 1½ times life size.

Each periscope extends horizontally for about two thirds of its length, then vertically to scanning position. Scanning heads are pointed away from "hot" reactor and into the scanning mirrors. This provides extra insurance against dangerous radiation finding its way through the tube to the observer.

Optical engineers faced a host of problems in building the long "scopes." One was the need to conserve light in the tubes. This was done by having a nonreflecting black coating on the inner walls and by spacing lens systems so they "pull" the light through the center.

Another problem was to keep an erect image even though the observer stands still while the scanning mirror moves. Submariners do not have this problem because the observer moves with the periscope.

This was solved by installing a motor-driven assembly of three mirrors. This assembly automatically derotates the image so that it always seems erect to the viewer.

Penetrate Fog for First Time in Long Research

Lighting engineers satisfactorily penetrated fog with automotive and highway-lighting equipment for the first time in a recent demonstration at Pennsylvania State University. This is believed to be the first major breakthrough in close to 100 years of scientific research to pierce the fog barrier.

The tests showed that it will be possible to increase visibility in fog on the open highway by 100%, or even more, through light control by changing the mounting angles of highway lighting, using low-mounted white fog lights, and polarizing the light sources, thus successfully accomplishing a major improvement in visibility in fog.

An audience of approximately 50 turnpike authorities from 10 states, highway safety experts, lighting engineers, psychologists, and ophthalmologists presented the latest results in a series of studies begun three-and-a-half years ago by the Illuminating Engineering Research Institute (IERI) at the request of the turnpike authorities in an effort to reduce the number of fatal and near-fatal accidents on the nation's highways.

Two co-operating groups of scientists, under the direction of the IERI, penetrated man-made fog, which has identical characteristics of natural fog, in the revealing tests which were staged in a 50-foot Army-type medical tent. Three separate types of lighting control were exhibited, each producing a notable although varying effect in penetrating a controlled fog barrier. Fog created inside the tent was equivalent to approximately 50-foot visibility on an open highway.

In the first light-control method, overhead roadway lights were mounted so that their beams were cast perpendicularly to the pavement. In the second method, reflector floodlights were installed on the shoulder of the simulated road and slightly above the pavement level so that the beams fell across the roadway perpendicularly to the autoist's line of sight. In the third method, automobile headlights and fog lights were dropped below the bumper level of the average car and, for maximum effect, were polarized.

Each of the three fog-penetrating systems demonstrated clearly proved that the fog barrier can be pierced satisfactorily when illumination is directed perpendicularly to the driver's line of sight or, in the case of auto headlights, as perpendicularly as possible.

Lighting, whether polarized or not, must be so arranged that the driver's line of sight does not travel along the beam of either his own headlights or of fixed highway lights.

Pieces of inexpensive polarizing material were used in the demonstration to filter the light sources. Maximum benefits were obtained when the resultant light was viewed through a similar filter mounted on a swing-away visor at the viewing point.

Although it is expected that the Research Institute's study program will be continued, and that additional findings will be made, it was suggested that corrective measures could be made on the basis of current knowledge.

A test installation on a major turnpike would satisfy one of the next steps that research scientists feel are now indicated.

It is felt that, in the current studies, qualitative objectives have been reached, and it has been shown that light can be made to penetrate a fog barrier and achieve a dramatically improved quality of vision. Now a quantitative objective must be attained. How to anticipate accurately the amount of visibility in any given fog situation must be learned and perhaps a formula established for use by highway officials to guide in designing the lighting and, in extreme cases, determining when to impose restrictions on road operations and when to suspend operations entirely.

Five Sources of Natural Energy Evaluated

New ways in which man can conserve the earth's dwindling fuel supplies by harnessing certain natural forces now mostly going to waste are described in a report released recently by the United Nations (UN), document *E/2997*.

Five specialists wrote background studies on each of the new energy sources. They were: on solar energy, Professor Farrington Daniels, chairman of the chemistry department of the University of Wisconsin, Madison, Wis.; on wind power, E. W. Golding, O.B.E., the Electrical Research Association, London, Eng.; on tidal energy, Robert Gibrat, professor of industrial power, École Nationale Supérieure des Mines, Paris, France; on geothermic energy, Dr. Ing. Remo Alessandri, director general of the Societa Iarderello, Florence, Italy; and on thermal energy of the seas, Christian Beau, inspector general of Bridges and Highways, Énergie des Mers, Paris, France.

The first section of what will eventually be a three-part volume describes the five natural energy sources.

The second and third parts of the report will consist of extracts from the technical background studies of the experts and a comprehensive annotated bibliography prepared by the UN Educational, Scientific and Cultural Organization.

Solar energy. The sun's radiation has long been used to heat greenhouses and to evaporate salt water for salt production. Modern exploitation of this energy source, still mainly in the research stage, is aimed at applying it to such varied purposes as cooking, heating and cooling of houses, refrigeration in tropical climates, the generation of electricity, and the smelting of minerals in solar furnaces.

One famous solar furnace is already in use. It was built as a prototype at Mont Louis in the French Pyrenees with 3,500 mirrors arranged in a parabolic focusing device 35 feet in diameter. This solar furnace has a capacity of 75 kw, and another French solar furnace a heat capacity of 1,000 kilowatts is planned.

To get an idea of what these figures mean in terms of what man can get in the way of useful energy from the sun, consider another and a much cruder way the sun's energy is used: through draft animals (whose fodder is raised by solar energy applied chemically). Scientists estimate the amount of useful energy provided by even the more powerful draft animals to be in the order of 750 kw-hr per annum. That means that the 75-kw solar furnace at Mont Louis can do as much work in 10 hours as a powerful draft animal can do in a year. And the solar furnace does not need to eat up valuable vegetable fodder or fuel.

A unique potential future application mentioned, on which much work may be going on but about which little information is available, is in the field of astronautics, or space travel. Solar power generation on artificial satellites has obvious advantages; for instance, the availability of solar energy is completely predictable, the radiation is more intense, and the transient energy source may eliminate the need to carry nuclear energy or other fuel.

Wind energy. Windmills are no novelty, but the sleek, streamlined wind machines of today bear little resemblance to the clumsy structures of the past. They look more like giant airplane propellers.

There is another important difference. Whereas in the past wind energy was used

mostly for mechanical power for mills or for pumping water, modern devices look more to harnessing the energy of wind for the production of electricity.

According to the report, electric windmills are in commercial production or actual operation in several countries, including Australia, Canada, Denmark, France, West Germany, the Union of South Africa, the U.S.S.R., the United Kingdom, and the United States.

Tidal energy. At certain places in the world the difference between high tide and low tide can be as much as 40 to 50 feet. In these favorable locations the enormous mechanical energy in the rising and falling of ocean tides can be harnessed and converted into electricity.

In principle, this process is akin to hydroelectric power, utilizing falling water. A basin is filled during flow tide and closed when the tide recedes so that a difference in head on ebb tide is created, or vice versa. When the water is allowed to fall toward the lower side of the barrage, which contains sluices and machinery, it runs a turbine which in turn drives a generator producing electricity.

New ideas and refinements have raised the interest in and the practical possibility of utilizing tidal energy. Instead of a single basin, two or more communicating basins may be built and utilized to give greater flexibility so that one basin generates power during the filling stage and another during the emptying stage, and water can be turbined between basins. More important, however, is the recent development of "bulb turbines" able to operate in both directions of water flow and also to act as pumps. After intensive research and the development of outstanding new technical contributions, France is going ahead with the first tidal project at La Rance. This is being built in stages from 1957 to the winter of 1963, when the last units in the 342,000-kw plant are expected to be put into service.

Other countries where possible tidal power plants are being considered are Argentina, Brazil, Canada, Germany, the Netherlands, New Zealand, Spain the U.S.S.R., the United Kingdom, and the United States.

Geothermic energy. Natural steam or hot water found in many parts of the earth, provided it occurs in sufficient pressure and volume, can be led through turbines to generate electricity.

Practical use of geothermic energy already is a fact in some countries. In Iceland, for example, the homes of one fourth of the population, as well as greenhouses and swimming pools, are heated by natural hot water.

In Italy, geothermic power facilities reached a capacity of 274,000 kw by the end of 1954 and gave an annual output of nearly 2 billion kw-hr. A tripling of geothermic power plant capacity and output in Italy by 1965 is foreseen.

Other geothermic plants planned or under construction can be found in the Belgian Congo, Chile, Japan, New Zealand, and the United States.

Geothermic energy can also be harnessed in such a way, in the more advanced installations, as to yield valuable chemical by-products.

Thermal energy of the seas. The history of this energy source, the only really new one of the five studied in the report, goes back barely 30 years. A French engineer first demonstrated the possibility of producing energy from a small temperature difference between two masses of water, and his idea was confirmed by experiments off Cuba a few years later. Intensified efforts in France during the last 15 years, including full-scale testing of components, are claimed to have solved the technical problems.

The capture and conversion into useful energy of heat stored in sea water represent an ingenious application of the principle that heat can be converted to mechanical work when two heat reservoirs of different temperature are available. In the case of the thermal energy of the seas, the temperature difference is relatively small (as low as 20 C or 36 F). The smallness of the temperature difference is more than made up for by the virtually unlimited quantities of sea water available.

This is roughly how it works: in many parts of the world where surface temperatures are high and the ocean floor is deep, frigid water from the polar regions, because it is heavier, slides down to the deeper regions. The water nearer the surface which is heated by the sun is considerably warmer.

The warm surface water is brought into a low-pressure vessel in which a partial vacuum is created by an air pump. (The total energy obtained through the process is much more than sufficient to take care of all the necessary pumping work involved.)

Under the reduced pressure, part of the warmer water "flashes" into vapor or low-temperature steam. The steam thus produced is "inhaled" by a condenser cooled by cold water pumped up from a deeper layer. (When the water vapor is condensed it takes up only a fraction of the volume it occupied as vapor; this causes more vapor to be sucked into the condenser as well as reducing the pressure in the warm water vessel.)

On its way from the warm water chamber to the condenser the steam passes through an extremely low-pressure turbine which in turn runs an electric generator. The condensed water vapor becomes useful fresh water as a by-product of the power-producing process.

No plant based on the thermal energy of the seas is yet operating, but one is being built at Abidjan, on the Ivory Coast of Africa. This project will have a net capacity of 7,000 kw of electric power. Furthermore, it could produce nearly 15,000 cubic meters, or about 4 million gallons, of fresh water every day.

On the economics of such plants, exclusive of the value of possible by-products such as salt, magnesium, and other chemicals concentrated in sea water, the report estimates that under the conditions at Abidjan, increasing the size of the plant from 7,000 to 100,000 kw might reduce the cost by two thirds. And an increase to 1 million kw might lower the cost to the order of 1 to 2 French francs, or 3 to 6 U.S. mills per kw-hr, claimed to be competitive for electro-steel mills.

Lines of development. The urgent need in the world's less developed regions for energy supplies—even of a random nature in small quantity—is emphasized. Although not always identical, the purpose for which energy is needed in those areas are not so diverse that research and development efforts could not easily be concentrated on a few essential devices. Universally, in these areas, electric power would be most valuable. The same can be said for the preservation of food and the establishment of means of communication among isolated villages. Primitive means of water pumping is a major reason for lack of sufficient irrigation, while in large arid and semi-arid areas the lack of fresh water is the stumbling block in the way of any reasonable development in the foreseeable future.

Priorities outlined. As suggested priorities, the following fields of research are most urgent: application of solar, wind, geothermic, and tidal energy to power generation in small units; of solar energy to telecommunication devices, to small refrigerating units, to water pumping, and to cookers; and of solar and thermal energy of the seas for the production of fresh water.

Sun Batteries for Helmet Radio and Satellite Instruments

Exposure to sunlight will be the only thing needed to operate a helmet radio being developed by the U. S. Signal Corps Engineering Laboratories, Fort Monmouth, N. J., as well as to provide an ideal power source for satellite instrumentation, because of the infinite life of the solar batteries utilized.

Experiments have proved that solar batteries, which convert light to electricity, can power the world's smallest transmitter-receiver. This helmet-housed radio with its tiny solar cell clusters, combined with rechargeable nickel-cadmium batteries, would provide power for many months and possibly a year or more. The success of these units give promise that similar power can be considered for use in walkie talkies and other light field radios.

Silicon wafers power the radio for normal daylight operations, and also charge the four storage batteries to supply peak daytime current as well as to operate the set at night.

The 50 volts needed are raised from the approximate 4.5 volts of the nickel-cadmium solar battery with a specially designed power converter. Careful investigation produced a completely transistorized converter small enough to fit into the aluminum housing along with the nickel-cadmium cells and the dry batteries.

To operate the instruments in the earth satellite, experiments have been conducted which proved that solar batteries would be the ideal power source. Army scientists attached glass-protected clusters of solar cells to the skin of an Aerobee-Hi rocket launched by the Navy at the White Sands Proving Grounds to prove this theory. The rocket was fired to an altitude of 190 miles, approximating satellite conditions, and at that height the tiny silicon wafer batteries functioned perfectly.

Interpretation of telemetered data from the soaring rocket indicated that the cells provided continuous electric output from the time of the firing until the rocket's radio ceased functioning when it re-entered the denser atmosphere closer to the earth's surface. Thus, solar cells attached to the satellite would supply power to the instruments therein.

AEC Reports

Sodium Reactor Experiment in California—Electric power was produced for the first time by heat from a Sodium Reactor Experiment (SRE) during tests of the reactor and auxiliary components.

The SRE, designed and built for the Atomic Energy Commission (AEC) by Atomics International, a Division of North American Aviation, Inc., is a part of the program to develop economically competitive civilian power from nuclear energy. The Southern California Edison Company has installed electrical generating equipment adjacent to the nuclear reactor to convert to electricity reactor heat energy which the company buys from the AEC.

The reactor is designed to produce 20,000 kw of heat from which the Edison equipment will generate approximately 6,500 kw of electricity. In the first test, the generator operated at a level of about 1,000 kw of electricity. The generating facilities will operate intermittently, depending upon the experimental operation of the reactor. The Edison Company will share with other power generating organizations this SRE information.

Heavy Water from U. S. Operates French Reactor—Chairman L. L. Strauss of the AEC has been advised that the French testing reactor, the *EL-3*, which is located at Saclay, France, has begun to operate on nuclear energy, utilizing heavy water made available to France by the AEC. Mr. Strauss was notified by a telegram from Pierre Guillaumat, administrator general of the French Atomic Energy Commission. The heavy water is used as moderator and coolant in the reactor.

The message expressed thanks for the heavy water and for assistance in negotiations of amendments to the "Atoms for Peace" agreement for co-operation between the United States and France, making available 2,500 kilograms of U-235 to advance the French nuclear program.

APPR Completes 700-Hour Performance Test—A 700-hour performance test of the Army Package Power Reactor (APPR) at Fort Belvoir, Va., has been successfully completed by Alco Products, Inc., which built the power plant for the AEC and the U. S. Army Corps of Engineers.

The power plant operated at a designated load for a period of 700 hours during which time shutdowns totaling only 8 hours were required for adjustment and repair of plant components. During more than 600 hours of the test, electricity was generated at a rate exceeding the design output of the power plant. A total of 1,181,000 kw-hr of electric power was produced during the 700-hour test. This amount of electricity normally would be sufficient to satisfy the needs of between 300 and 400 average homes for one year.

The APPR is a prototype small package power reactor designed to furnish power to remote military installations. In such locations, the cost of electricity from diesel plants is such that this type of nuclear power plant will offer competitive advantages.

First Development Reactor License Issued—The AEC has filed notice that it proposes to issue developmental power reactor license number 1 to the General Electric Company (GE) for operation of a power reactor in Alameda County, Calif.

The facility is a boiling water reactor which GE expects to operate initially at a thermal power level of 20,000 kw, furnishing heat for the production of 5,000 kw of electricity.

A primary purpose of the reactor is to furnish technical data for the full-scale boiling water power reactor which GE is building for Commonwealth Edison Company's Dresden generating station, Grundy County, Ill.

Revolutionary Semiconductor Amplifier

The "Spacistor" is said to be a new kind of semiconductor devised to overcome the frequency limitations of the transistor by avoiding the slow diffusion of charge carriers (electrons or "holes") through the base region. Carrier motion across the base region of a transistor is slow because this region is essentially field-free. It is true that the base region of a diffused transistor has a built-in field, but its strength is severely limited.

Much higher field strengths are found, however, in space-charge regions in reverse-biased junctions. In fact, field strength is limited only by the breakdown voltage of the semiconductor body. The Spacistor utilizes these high fields to accelerate the charge carriers so that their transit time is greatly shortened, it was stated by Raytheon Manufacturing Company engineers.

A low-frequency power gain of 70 db has been achieved with experimental Spacistors at low frequencies. It is thought that a comparable advantage will be realized over transistors at the higher frequencies. When the present input of 30 megacycles (mc) is improved, power gain will become so great that it will be more appropriate to talk about voltage gain as in the case of a vacuum tube. A voltage gain of 3,000 has already been achieved.

Another important advantage of the unit is that its operation is practically independent of charge-carrier "lifetime." It should, therefore, be feasible to employ not only germanium and silicon, but also those other semiconductor materials which have short lifetimes that make them unsuitable for transistors. Silicon carbide and other materials with large energy gaps are promising possibilities for spacistors.

Activities of Other Societies

AIME—The Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers has announced that S. D. Michaelson of Salt Lake City, Utah, who is chief engineer of the Western Mining Division of the Kennecott Copper Corp., has been nominated for 1958 president of the society. He also will serve as a director of AIME.

NSPE—G. H. Dyer, director of the Missouri Water Company and manager and chief engineer of the Independence Division of the firm, has been elected president of the National Society of Professional Engineers. Six regional vice-presidents and a treasurer were also elected for the administrative year beginning July 1957. The new vice-presidents are: A. H. Kidder, Philadelphia, Pa., Northeastern Region; J. B. McGaughy, Norfolk, Va., Southeastern Region; H. G. Kennedy, Charleston, W. Va., Central Region; W. L. Hindermann St. Paul, Minn., North Central Region; C. A. Dunn, Stillwater, Okla., Southwestern Region; and L. R. Durkee, Seattle, Wash., Western Region. Elected for his 10th term as treasurer was R. B. Allen of College Park Md.

NACE—Students from 35 engineering colleges have been invited to attend the October 2-4 meeting of the North Central Region to be held at the Hotel Sherman, Chicago, Ill. Registration for the meeting of the North Central Region of the National Association of Corrosion Engineers will begin the evening of October 1st. The Northeast Region meeting to be held in Pittsburgh, Pa., November 12-14 has scheduled 11 meetings of technical committees with a formal technical program of 19 papers and 6 symposia to follow.

Danish Reactor Is Put into Operation

Denmark's first nuclear reactor was put into operation in August. Designed and built by the United States firm of Atomics International, it is the first solution-fuel research reactor built by the company to "start up" while using the 20% enriched uranium allotment set up by the United States Government for shipment to foreign countries.

Supervising the criticality of the Danish installation was one of the company's engineers who handled all the precritical and criticality tests over a period of several months.

The facility which houses the reactor is located at the new Danish Atomic Energy Commission's Nuclear Research Center on Riso Peninsula, some 20 miles from Copenhagen.

The reactor is used for nuclear engineering and training, radioisotope production, and for research in the physics, medicine, chemistry, and agriculture fields.

The model *L-55* reactor, known as "Nulenergiopstilling" (a term relating to its low power) in Denmark, is designed to operate at a power level of 5 watts normally. Provision is made for operation up to 500 watts by integrating additional cooling equipment with the present cooling coil within the reactor core.

Criticality of the reactor was achieved with 984 grams of fuel, thus meeting the original calculations made when the reactor was first designed.

Trade Fair of the Atomic Industry in New York

AtomFair, as the 1957 Trade Fair of the Atomic Industry is called, will be an event

of outstanding importance not only to those individuals who are concerned with supplying products and services for the nuclear field, but also to those who are using or expect to use the products of this expanding industry.

Members of all societies are invited by the Atomic Industrial Forum to attend AtomFair '57, which will be held at the New York Coliseum from October 28 through October 31. In conjunction with the fair, a number of important nuclear activities have been planned, such as the Forum's annual industry conference, the winter meeting of the American Nuclear Society, the first Reactor Safety Conference (cosponsored by the U. S. Atomic Energy Commission), the 2nd Conference on Careers in Nuclear Science and Engineering, and the annual meeting of the professional group on nuclear science of the Institute of Radio Engineers.

On making request to the Forum, members of any society or organization will be able to obtain complimentary AtomFair tickets. All ticket requests should be made on business letterhead and addressed to:

AtomFair
3 E. 54th St.
New York 22, N. Y.

Participation in any or all of the events that have been scheduled will be beneficial to persons in any of the allied fields as well as to those directly connected with the ever-expanding nucleonics field.

Those who wish to participate in either the meetings or the exhibits should contact

D. J. Scherer
c/o Atomic Industrial Forum
3 E. 54th St.
New York 22, N. Y.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

APPLIED RELIABILITY. Proceedings of the Second RETMA Symposium, June 1957. Published 1957 by Engineering Publishers, GPO Box 1151, New York 1, N.Y. 93 pages, 8½ by 11 inches paper. $5. The 15 papers included in this symposium on electronic equipment are broadly classified in the following sections: selection and use of components, principles of techniques of mechanical design, measurement and proof of mature design, and case histories of specific pieces of equipment. These papers deal not only with the basic factors for reliability in operation, but also with specialized aspects of construction and operational conditions, and with failure prediction techniques.

ATOMIC ENERGY APPLICATIONS WITH REFERENCE TO UNDERDEVELOPED COUNTRIES. By B. C. Netschert, S. H. Schurr. The Johns Hopkins Press, Homewood, Baltimore 18, Md., 1957. 129 pages, 6 by 9 inches paper. $2. The first part of this booklet reviews the uses of nuclear energy. Part II discusses the conditions necessary for using nuclear energy in terms of meeting requirements in cost and resources, and in terms of conditions necessary to derive any benefit from a particular use. The last part of the book describes the activities already undertaken to initiate nuclear energy programs in underdeveloped countries.

BASIC AUTOMATIC CONTROL THEORY. By G. J. Murphy, D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J., 1957. 557 pages, 6 by 9¼ inches, bound. $9. The basic theory pertinent to the analysis and synthesis of linear control systems having only fixed, lumped parameters, and subject to input commands and disturbances which can be specified with certainty is the subject of this college textbook. Among topics covered are types of control systems; ultimate-state, frequency and time response; and introduction to use of the analog computer.

THE DEMAND AND SUPPLY OF SCIENTIFIC PERSONNEL. By D. M. Blank, G. J. Stigler. National Bureau of Economic Research, 261 Madison Ave., New York 16, N.Y., 1957. 200 pages, 6¼ by 9¼ inches, bound. $4. This important study offers evidence that, contrary to many previously published reports, there is no shortage of engineers in the United States. The study consists of five chapters dealing, respectively, with the growth of the technological professions, demand and supply, factors influencing the demand for engineers and chemists, the supply of engineers, and supply and demand for mathematicians and physicists. A considerable amount of statistical data is included in appendixes.

ENGINEERING ELECTRONICS. By J. D. Ryder. McGraw-Hill Book Company, 330 W. 42nd St., New York 36, N.Y., 1957. 666 pages, 6½ by 9¼ inches, bound. $9.50. Devoted to the nonradio areas of electronics—signals, methods of control, instrumentation, etc.—this book emphasizes the underlying principles and basic circuits applicable to various devices and equipment. The first three chapters are a survey of fundamentals; the remaining chapters take up specific devices and circuits such as amplifiers, switching circuits, filters, oscillators, transistors, photoelectric devices, and servomechanisms. The book is intended as a text for seniors and for use by practicing engineers.

HÜTTE. Volume IV Electrotechnik: Part A, Starkstromtechnik; Lichttechnik. Wilhelm Ernst & Sohn, Berlin, Germany, 28th edition, 1957. 946 pages, 4¼ by 7¼ inches, bound. DM 49. This well-known, standard reference work, covering the entire field of engineering, has now been expanded to nine volumes. The present volume comprises a comprehensive treatment of heavy-current technology: operation, selection, and testing of electrical machines; transformers and induction coils; power transmission and distribution; current regulators; electric heating; low- and high-voltage switching; as well as such generalized topics as the materials involved, standards, and symbols. The volume also covers the theory and practice of illumination. A detailed, 30-page index is provided.

LIGHT SCATTERING BY SMALL PARTICLES. By H. C. van de Hulst. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1957. 470 pages, 5¼ by 9¼ inches, bound. $12. An authoritative explanation of available data concerning phenomena of importance in many fields of science. For simplicity the author restricts himself to dealing with single scattering by independent particles with the assumption that the scattered light retains the same frequency as the incident light. Usable graphs and numerical results are provided throughout the book, particularly in Part II which covers a great variety of special particles, and Part III which demonstrates selected applications in physics and chemistry.

LINEAR PROGRAMMING; AN EXPLANATION OF THE SIMPLEX ALGORITHM. By D. U. Greenwald. The Ronald Press Company, 15 E. 26th St., New York 10, N.Y., 1957. 75 pages, 5¼ by 8¼ inches, bound. $3. Linear programming may be described as a mathematical technique for determining the most effective course of action when a situation is governed by many known variables and conditions. In this small book a simplified technique is presented which is applicable to a great many engineering and management problems. A number of concrete examples, chiefly from production engineering, are here worked out, and mention is made of other books, on refinery problems for example, for which this book is a useful introduction.

NONLINEAR CIRCUIT ANALYSIS. Proceedings of the Symposium, New York, 1956. Published 1957 by the Polytechnic Institute of Brooklyn, Brooklyn, N.Y. 456 pages, 6 by 9 inches, bound. $5. This is the 6th volume in the Symposia Series of the Microwave Research Institute of the Polytechnic Institute of Brooklyn and the 2nd volume devoted to nonlinear network theory. The technical papers are grouped by sessions devoted to recent progress in theory, circuit design, feedback systems, methods, and discontinuous systems.

PRACTICAL AUTOMATION. By L. R. Bittel and others. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1957. 376 pages, 8¼ by 11¼ inches bound. $7.50. A practical guide to the installation and use of plant automation. In addition to the general discussions of fundamentals and specific recommendations for planning, operation and management, over 150 actual cases, small and large, in existing plants, are described. The text material, profusely illustrated by photographs and diagrams, covers handling, processing, inspection, and maintenance operations, controls instrumentation, communication systems, and computer applications.

PRACTICAL R-F HEATING FOR THE WOOD INDUSTRY. By J. Pound. Heywood & Company Ltd., London, England, 1957. 198 pages, 5½ by 8¾ inches, bound. 30s. For the practical woodworker this book presents information on radio frequency (R-F) heating as used with adhesives in joining wood to wood. There is extensive treatment of transverse, blueline, and stray field heating. In addition to the manufacture of plywood, there are applications in furniture and boat-making. A chapter on other heating methods rounds out the text. There is a glossary and a bibliography for those who wish more theory on this subject.

PRÉCIS DE MAGNÉTOSCOPIE. By E. W. Müller. Dunod, Paris, France, 1957. 169 pages 6¼ by 9½ inches, paper. Fr. frcs. 1880. A French translation of a work by a German authority on magnetic testing of steel (flaw detection). Chapter I on principles deals with the magnetic field and its production, the use of magnetic powders, and the sensitivity of the method. Chapter II provides examples of applications to machine parts and welded joints, particularly some of the more difficult cases. The three subsequent chapters cover demagnetization, economic considerations, and literature references.

PRINCIPLES OF ENGINEERING INSPECTION. By G. K. King and C. T. Butler. Cleaver-Hume Press, Ltd., London, England, 1957. 264 pages, 5¾ by 8¾ inches bound. 25s. A concise, practical treatment of equipment and methods of test for inspection in manufacturing, covering inspection of metallic and nonmetallic raw materials; forgings, casting, welds, and other types of primary production; machined components; and surface finish. The book also deals with the design and manufacture of gauges, statistical quality control, and setting up an inspection system. Line drawings illustrate the working of the many testing machines described.

RADIOACTIVITY AND NUCLEAR PHYSICS. By J. M. Cork. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J., third edition, 1957. 415 pages, 5½ by 8¼ inches, bound. $7.75. Although prepared as a college text, this book may also serve as a useful handbook for workers in allied fields and a refresher for those reviewing present developments in the field. This edition brings discoveries in the nucleus of the atom up to date and describes advances in the design of accelerators and detectors. It also reviews the well-established domains of modern nuclear theory, and touches upon the history of radioactivity, natural and induced. The brief sketches on applications of radioactivity run the gamut of fields of scientific endeavor.

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS. Edited by A. E. Knowlton.

McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 9th edition 1957. 2230 pages, 6 by 9¼ inches, bound. $19.50. This standard reference tool has been revised and broadened in scope to cover the many innovations and developments in the electrical field in the last decade. Experts in each area have reviewed the 26 major sections of the book thoroughly and provided new or expanded data on nuclear power, dielectrics, transistors, telemetering, electrical measurement for automation, etc. Information on new synthetic materials and recent metals has also been included as well as electric conductor tables based on latest American Society for Testing Materials (ASTM) standards, and new international electrical units and values.

TRANSDUCTORS AND MAGNETIC AMPLIFIERS. By A. G. Milnes. Macmillan and Company, Ltd., London, England; St. Martin's Press, 103 Park Ave., New York 17, N. Y., 1951. 286 pages, 7½ by 10 inches, bound. $12.50. A monograph intended both for the specialist and nonspecialist, with chapters for the latter on basic theory, construction and elementary circuit technique, magnetic amplifier applications, four-limbed transductors, magnetic core devices, and reset transductors. Chapters for the more advanced reader are those dealing with series transductor theory, auto-self-excited circuit behavior, push-pull circuit theory, a-c control, three-phase circuits, and transistor control of magnetic amplifiers. Over 150 references are listed at the end of the book.

TRANSISTOR CIRCUIT ENGINEERING. Edited by R. F. Shea. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1957. 468 pages, 5¾ by 9¼ inches, bound. $12. After presenting some basic transistor theory, the greater part of the book is devoted to the use of transistors in a wide range of fields including audio, d-c, tuned, and video amplifiers. There are also chapters on oscillators; modulation, mixing, and detection; transient response and pulse circuits; and special circuits.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

SERVOSYSTEMS LABORATORY MANUAL. Prepared for Servo Corporation of America with the guidance of a group of outstanding controls teachers and engineers, Servosystems Laboratory Manual is the first step in a long-range program of service to engineering education. Designed to be useful to both industries and schools, the manual furnishes framework for an introductory laboratory course in servomechanisms, feedback control systems, etc. Seven integrated, class-tested experiments are included in the manual and each of them builds on what the student has learned in the earlier experiments. The experiments call for the breadboarding of a basic servosystem which is used throughout the course. Practical applications of principles are stressed and theoretical material is kept to a minimum because the manual is intended for use in conjunction with any of the standard texts in the field. The 32 pages include numerous diagrams and photographs. It is available from the Educational Services Department, Servo Corporation of America, 2020 Jericho Turnpike, New Hyde Park, N.Y. Price is $2.

THE USE OF SELENIUM PHOTOCELLS AND SUN BATTERIES. Designed to be of primary interest to scientists and engineers, this handbook contains 84 pages of technical information, illustration charts, and diagrams which describe detail applications and devices in which sun batteries and other photocells are successfully used. Copies may be obtained for $1.50 from International Rectifier Corp., El Segundo, Calif.

NATIONAL SCIENCE FOUNDATION PUBLICATIONS. Available to all scientists who have need for them. Lists of publications are available from the Foundation. Requests should be addressed to the Publication Office, National Science Foundation, Washington 25, D.C.

MAKING, SHAPING, AND TREATING OF STEEL. The most complete one-volume reference work relating to the iron and steel industry has been published in its 7th edition by United States Steel Corporation. Completely revised since its 6th edition was issued in 1951, the new volume offers users and makers of steel a comprehensive summary of present-day theory and practice covering all phases of iron and steel production from raw materials to finished products. The new edition is the result of team effort by nearly 200 technical representatives of U. S. Steel, its operating divisions and subsidiaries, coordinated by H. E. McGannon, technical editor, under the direction of Dr. E. C. Bain, assistant executive vice-president—operations. The book, containing 932 pages of text, 773 illustrations, and 126 tables, is divided into 50 chapters, which are subdivided into sections. Each chapter and section is made as nearly independent of others as possible. An extensive index simplifies use of the book for reference work. Copies of the volume, priced at $7.50 each, may be obtained from United States Steel, Office Service-Stores, 525 William Penn Pl., Pittsburgh 30, Pa. Students of accredited educational institutions may obtain the book for $5 per copy, provided each order is countersigned by a faculty member.

CONVERSION TABLES—U. S. TO METRIC SYSTEM, METRIC TO U. S. SYSTEM. Scientists, engineers, designers, production men, exporters, and students are frequently required to convert from the U. S. system of units to the metric system or vice versa. To do this is not difficult; however it is a tedious manipulation. More often than not, the appropriate conversion factors are not on hand. These conversion tables are a practical, simple aid for every person faced with this problem. To convert units of length, weight, and volume from one system into the other no calculation is required, the appropriate answer is obtained by reading it directly from the proper table. The use of this booklet will save time, aggravation, and will eliminate costly errors. It may be obtained by sending $1 to M. Stand, 527 Lexington Ave., New York 17, N.Y.

HANDBOOK FOR URANIUM PROSPECTORS. A revised edition of the popular pocket-sized handbook for uranium prospectors, "Prospecting for Uranium," is available from the Superintendent of Documents, U. S. Government Printing Office. The booklet is jointly published by the U. S. Atomic Energy Commission (AEC) and the U. S. Geological Survey. The price is 75¢ per copy. The revision includes an enlarged section on the geologic occurrence of uranium based on the large amount of new information developed during the growth of the uranium industry since the earlier edition (1951). The revision also includes information on the domestic uranium procurement program announced in May 1956, the latest AEC uranium price circulars and an up-to-date compilation of laws and regulations affecting uranium mining. The booklet is designed to answer inquiries received by Government agencies as a result of the AEC's domestic uranium procurement program. Approximately 266,000 copies of the earlier editions were sold. Orders for the revised edition are being accepted by the Government Printing Office, Washington 25, D.C.

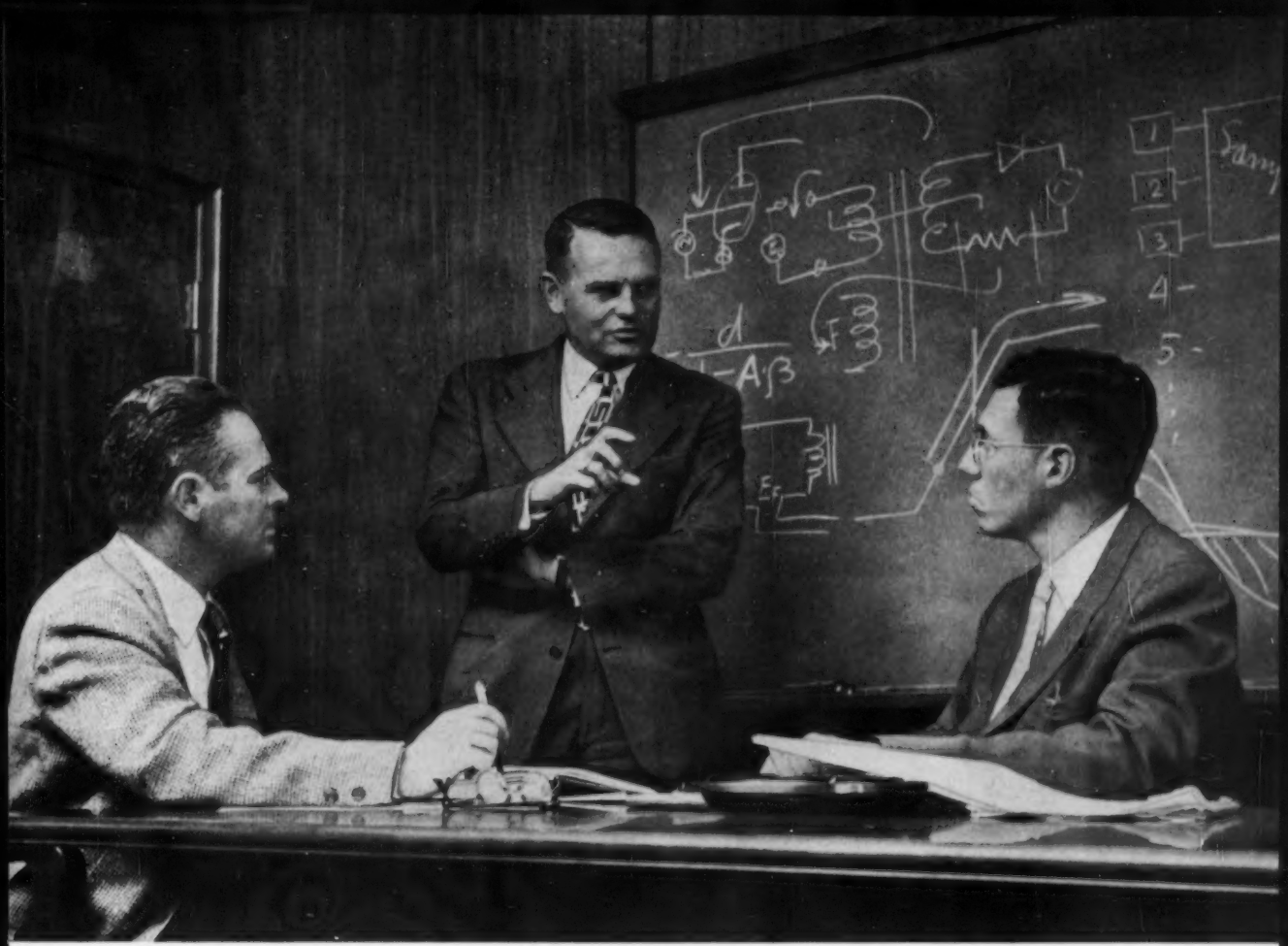
LONG-PERSISTENCE THREE-COLOR INDICATOR CATHODE-RAY ELECTRON TUBE. Shadow-mask multicolor storage tubes for radar and other applications with low frame rates have been constructed for the Air Force. The development is described in a report of research made available to industry through the Office of Technical Services (OTS) U. S. Department of Commerce. Design of the tubes was directed toward providing long-persistence displays of high brightness. Such color displays reduce flicker and tend to provide a steady picture. They also permit additional information to be superimposed on the radar display. The multicolor storage tube was built by modifying a direct-viewing storage tube. It showed good color purity in a 6-inch diameter circle. The tube has 75 total color dots per inch resolution, 8 foot-lamberts brightness, and about 1-minute persistence.

Further details are in *PB 121815*, by C. D. Beintema, L. L. Vant-Hull, S. T. Smith, The Hughes Aircraft Company for Wright Air Development Center. May 1956. The report may be ordered from OTS, U. S. Department of Commerce, Washington 25, D.C. It contains 29 pages, price 75¢.

INTRODUCTION TO PRINTED CIRCUITS. By R. L. Swiggett, executive vice-president of Photocircuit Corporation. A really basic and comprehensive text on printed circuits, this 112-page book gives complete coverage of the processes used for the manufacture of ceramic based, etched, plated, stamped, pressed powder, embossed wiring, double foil, and die blanked printed circuits. The book describes the servicing techniques and problems associated with printed circuits. A full chapter is devoted to the components composed of, and used with, printed circuitry. These include such items as resistors, potentiometers, capacitors, tube sockets, switches, rectifiers, etc. The text and associated illustrations show how these components are combined into a finished product. Another chapter devotes itself to the various types of assembly systems used in mass production of printed circuits and printed circuit devices. Published by John F. Rider Publisher Inc., 116 W. 14 St., New York 11, N.Y. $2.70 per copy.

RCA TRANSISTORS AND SEMICONDUCTOR DIODES. This 24-page booklet has been published by the Radio Corporation of America (RCA) Semiconductor Division. E. F. Neuner, marketing manager, announced. The booklet contains a general explanation of transistor theory and operation, with a special section devoted to the RCA-developed "drift" type transistor. Complete characteristic data on the 18 RCA types of transistors and 4 semiconductor diodes are supplemented by equivalent circuits and dimensional outlines. Another feature of the booklet is an Interchangeability Directory. This directory has been prepared in a handy form to guide the designer, experimenter, and serviceman in selecting the proper RCA transistor type as a replacement, and to help identify and describe many of the transistor types introduced by different manufacturers. The listings contain more than 500 type designations including junction and point contact types. The booklet concludes with 8 pages of circuit diagrams which illustrate 20 of the more interesting applications of RCA transistors and diodes. Among these schematics, complete with values of components and coil winding details, are two- four- and six-transistor receivers, phonograph preamplifiers, sensitive relay, low-drain power supply, code practice oscillator, hearing aid, and many others. Copies of the booklet may be obtained from RCA distributors or by sending 25¢ for each copy to RCA Commercial Engineering, 415 S. Fifth St., Harrison, N.J.

A PROFILE OF THE ENGINEER. The engineer, currently one of industry's most precious resources, is the subject of a comprehensive study that offers the harried company recruiter a scientific basis for attracting new talent in a continuing tight market and for reducing the high rate of engineer turnover. In "A Profile of The Engineer" (a series of three reports), the research department of Deutsch & Shea, Inc., consultants in the technical manpower field, has provided the first detailed portrait of the American engineer as a man and as a professional—his intelligence and abilities, his distinctive personality traits, social attitudes, work habits, and recreational interests. The study, which brings together and analyzes many hitherto isolated findings, pinpoints the personality factors involved in engineer job satisfaction. Are all engineers alike? While most engineers share many distinctive traits, there is a narrow, though important, range of temperamental differences to be found among engineers in different fields. One of the features of the Profile is an elaborate chart listing the outstanding characteristics of engineers in each of the six chief engineering functions. In addition, there is a table summarizing important investigations of engineer personality characteristics, an appendix listing the better-known engineer aptitude tests, and extensive bibliography. The three reports are available at $7.50 per set from Industrial Relations News, 230 W. 41st St., New York 36, N.Y.



Staff Scientist Dr. J. W. Muehlner (center) discusses an advanced PDM telemetering system for missile application with K. T. Larkin (left), Telecommunications Department manager, and J. R. Dawley, Telecommunications Systems Section head.

New positions in

MISSILE SYSTEMS TELECOMMUNICATIONS

Weapon systems programs at Lockheed Missile Systems demand advances far exceeding the current state of telecommunications. Positions are open on the Palo Alto and Sunnyvale staffs for scientists and engineers possessing a high level of ability and interest in:

TELEMETRY – Research in various areas of physics and electronics related to advanced telemetering projects; theoretical analysis of advanced FM, PDM, PCM System concepts; design integration of all phases of telemetry with weapon systems requirements; conception and development of original high-capacity and high-accuracy systems; development and package design of airborne telemetering equipment capable of operating under extreme environmental conditions, including transducers, subminiaturized subcarrier oscillators, crystal controlled FM transmitters, solid state commutators, PDM keyers, digital storage and conversion devices; development and prototype design of ground telemetry equipment to include devices such as high-efficiency decommutators, calibrators, digital encoders.

COMMUNICATIONS – Application of information theory concepts to challenging communication link problems; analysis and design of microwave communication link components to be utilized in most advanced weapon systems; development and test of television links for special projects.

Address the Research and Development Staff at Sunnyvale 43, California.

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INDUSTRIAL NOTES

General Electric. A new electronic computing device for measuring, counting, and classifying time of flight of neutrons from a nuclear reactor which accomplishes in an hour what previously would have taken a man a month to do has been developed by the Knolls Atomic Power Laboratory, Schenectady, N. Y. Savings in time and labor by the new analyzer are matched by the space it conserves at the laboratory, operated by General Electric for the Atomic Energy Commission. The device is only 8 inches high, 19 inches long, and 13 inches deep, compared to earlier analyzer equipment which took up at least 10 times that amount of space at the laboratory. The entire operation from neutron count to production of a graph which reveals the energy spectra of the reactor requires only about an hour.

Laminate Bonding. In the field of metal joining, laminate bonding with adhesives is rapidly taking its place alongside the older stand-by methods of welding, riveting, and fastening. Although relatively new, this modern joining process is already being used successfully by automotive and aircraft companies, plus dozens of other manufacturers, in scores of different bonding applications. Many companies are using it to join dissimilar metals. Others find it a highly practical method of joining metals to nonmetals including glass, plastics, wood, and ceramics. For further information contact: The Fostoria Pressed Steel Corporation, Fostoria, Ohio.

IT&T. As a result of the organizational changes in the International Telephone and Telegraph Corporation (IT&T) system, the electronic instrument manufacturing and distribution activities formerly conducted by the Instrument Division of Federal Telephone and Radio Company, an IT&T Division, have been assigned to the recently created Industrial Products Division of IT&T. The instrument organization's headquarters will remain at 100 Kingsland Rd., Clifton, N.J. Federal Instruments specializes in the manufacture and sale of large-screen oscilloscopes, bar graph oscilloscopes, swept frequency generators, and similar precision instruments and instrumentation systems, as well as the distribution of Rhode & Schwarz and other imported precision test equipment.

Marine Corps Radio Pack Set. A small, man-carried radio transmitter and receiver to meet new requirements for range and reliability is being developed for the United States Marine Corps by the Research and Advanced Development Division of Avco Manufacturing Corporation, 20 South Union St., Lawrence, Mass. The set will be based on a radically new transistorized design conceived at the Division's Electronics Research Laboratory in Boston, Mass. A Navy contract calls for a design study and development of a prototype set. Solid-state techniques will be employed throughout the design. The latest modulation techniques and rechargeable batteries will be used.

Slip Ring Division. Electro Mechanical Products Company, 32700 Ford Rd., Garden City, Mich., has established a new slip ring division for the development and manufacture of slip rings for aircraft, ordnance, and marine purposes. Increased activity particularly in the aircraft and missile fields has necessitated the change.

New Generating Station. Bergen Generating Station will be the third completely new station (following Sewaren and Linden) to be added to the Public Service electric system in New Jersey since the original Kearny Generating Station project went into service more than 30 years ago. Bergen will have two 290,000-kw units, each more than 1½ times as powerful as the combined capability of the original five-unit "giant" at Kearny. Bergen will generate twice as many kilowatt-hours from a ton of coal as the old Kearny equipment. The turbine generators are the prototype of a new concept in the design of cross-compound machines sponsored by the Electric Engineering Department and developed by Westinghouse Electric Corporation. Both elements of each cross-compound machine are exact duplicates in all respects except that one shaft has the high pressure steam cylinder and the other has the intermediate pressure steam cylinder. The 3,600-rpm low-pressure cylinders and the generators are duplicates. Throttle steam conditions at Bergen will be 2,350 psig and 1,100 F, with reheating to 1,050 F. For further information contact Public Service Electric and Gas Company, 80 Park Place, Newark 1, N. J.

Light and Vision Institute. The Holophane Light and Vision Institute (L & V) has become famous as the lighting education center of the East Coast. To keep ahead of the rate of change, the L & V has been rebuilt. It is a unique demonstration and lecture hall, an impressive show place, and a center for the solution of lighting problems. Here architects, engineers, and users of light can get up-to-the-minute lighting advice. It has facilities for the demonstration of all kinds of prismatic light control and for the showing of the newest developments in lighting equipment, sources, and methods. The latest invention in space lighting, the PRISMALUME (registered trade mark) ceiling, from which a soft, completely comfortable radiance results at daylight levels lights the L & V. A mirror spans the entire back wall of the auditorium reflecting the PRISMALUME ceiling. For further information, communicate with H. L. Logan or Gunther Lanson, Holophane Company, Inc., 342 Madison Ave., New York 17, N. Y.

(Continued on page 22A)

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for Transistors and Strain Gages

A NEW COMPACT, LIGHT WEIGHT UNIT FEATURING TWO INDEPENDENT REGULATED VOLTAGES WITH HIGH EFFICIENCY, FAST RECOVERY TIME, GOOD STABILITY, LOW OUTPUT IMPEDANCE, LOW HEAT DISSIPATION, AND SHORT CIRCUIT PROTECTION.

OUTPUT #1

OUTPUT VOLTAGE DC: 0-30 volts continuously variable.
OUTPUT CURRENT DC: 0-1.5 amperes continuous duty.
REGULATION: In the range 0-30 volts, the output voltage variation is less than 0.02 volts for load variation from 0 to maximum current, and less than 0.02 volts for line fluctuation from 105-125 volts.
RIPPLE VOLTAGE: Less than 3 millivolts RMS.
FUSE PROTECTION: Input and output fuses on front panel.

OUTPUT #2

OUTPUT VOLTAGE DC: 0-30 volts continuously variable.
OUTPUT CURRENT DC: 0-1.5 amperes continuous duty.
REGULATION: In the range 0-30 volts, the output voltage variation is less than 0.02 volts for load variation from 0 to maximum current, and less than 0.02 volts for line fluctuation from 105-125 volts.
RIPPLE VOLTAGE: Less than 3 millivolts RMS.
FUSE PROTECTION: Input and output fuses on front panel.

RECOVERY TIME: Less than 50 microseconds. The excursion in the output voltage during the recovery period is less than .05 volts for line fluctuations from 105 to 125 volts or load variations from 0 to maximum current.

STABILITY: The output voltage variation is lesss than .05 volts for a period of 8 hours.

OUTPUT IMPEDANCE: Less than 0.1 ohms from 1KC to 100KC. Less than 0.01 ohms from DC to 1KC.

POWER REQUIREMENTS: 105-125 volts, 50-400 cycles.

OUTPUT TERMINATIONS: DC terminals are clearly marked on the front panel. All terminals are isolated from the chassis. Either positive or negative terminal of each DC output may be grounded. A terminal is provided for connecting to the chassis. The DC terminals are also brought out at the rear of the unit.

PHYSICAL SPECIFICATIONS: Height 7", width 19", depth 11", color gray hammertone. This unit is designed for relay rack mounting or bench use. Carrying handles are provided.

METERS: Voltmeters: Two 0-30 volts, 2½"
Milliameters: Two 0-1.5 amperes, 2½"

CONTROLS: Power on-off switch; outputs 1 and 2 DC on-off switch; outputs 1 and 2 ten turn voltage controls.

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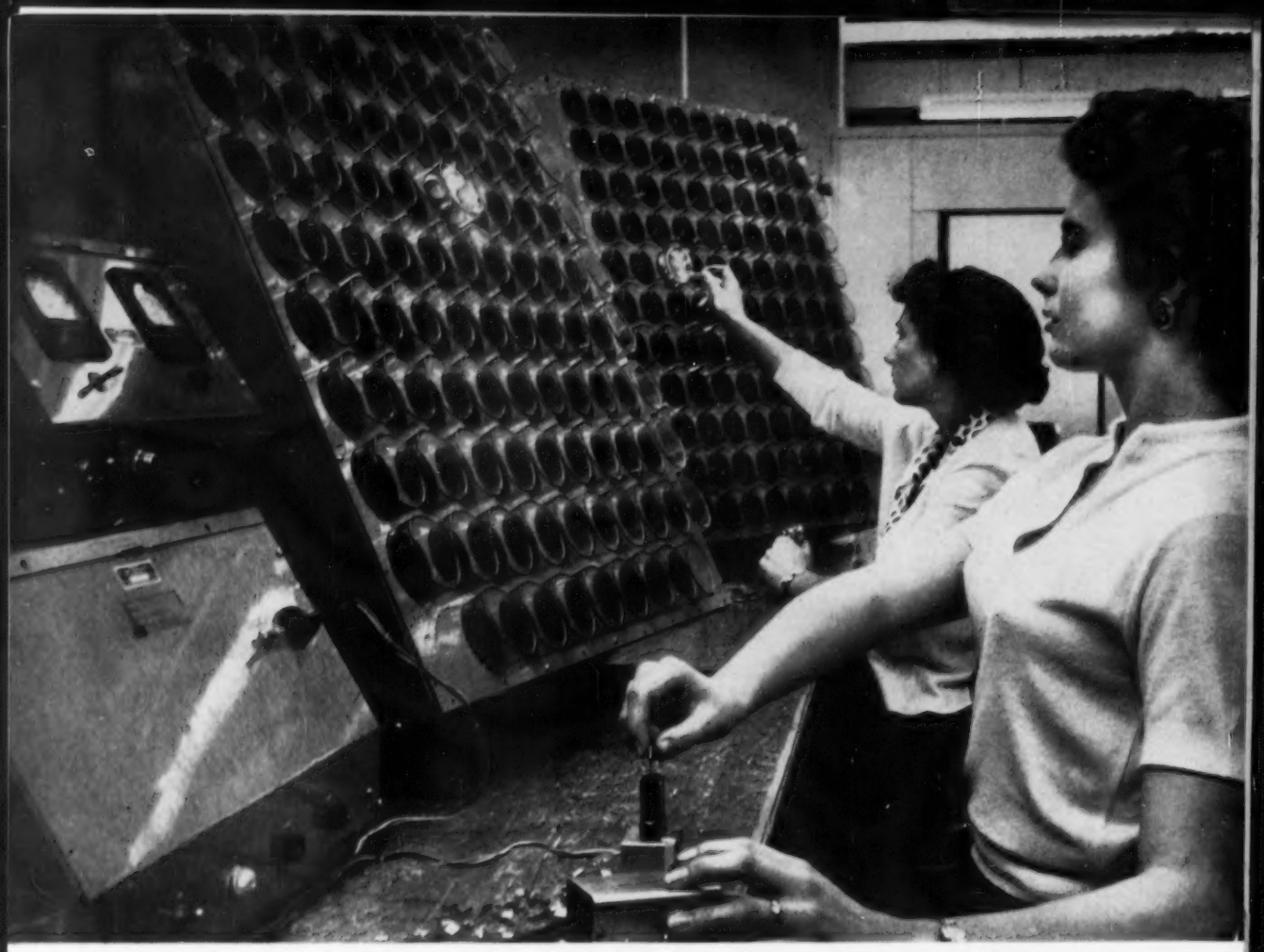

lighting a transistor's way home . . . automatically!

Homely articles like water glasses and light bulbs are used in this automated selector built by TI mechanization engineers. Now, non-technical TI-ers close a circuit with a transistor just off the production line; wait a second for the circuit to evaluate it; then pop the unit into the glass that lights up. This "matching" operation is another advance toward automation of semiconductor manufacture . . . to free technical personnel for other important duties . . . to help Texas Instruments produce more electronic components and apparatus at lower cost.

This special application is typical of the many special engineering opportunities now open at Texas Instruments . . . openings for industrial engineers, machine designers, automation engineers, and other specialists to fill a continuing need to develop the mechanics for making things that have never been made before. Eighty per cent of today's TI products are new to its production lines within the last 3 years.

You are invited to join one of the many expanding programs at 27-year-old Texas Instruments . . . where recognition of individual achievement has contributed to TI's twentyfold growth in the last ten years – to a current $70 million volume. Advanced personnel policies include company-sponsored educational assistance, profit sharing, insurance, and retirement programs.

Texas Instruments plants are within Dallas, yet away from downtown traffic . . . within 5 minutes of fine residential areas, churches, and public and private schools. Your home will be within 15 minutes of year-around recreational, amusement and cultural activities.

SEMICONDUCTORS AND OTHER COMPONENTS – Design engineering, industrial engineering, production coordination, product evaluation, mechanization for making transistors, diodes, rectifiers, resistors, panel instruments. Write W. C. Spaller.

ELECTRONICS AND ELECTROMECHANICAL APPARATUS – Radar, sonar, infrared, navigation, magnetics, telemetering, communications, computers, transformers. Write R. E. Houston.

RESEARCH – Ph.D. level for research: semiconductor materials and devices, ferromagnetics, infrared, high speed data reduction, etc. ADMINISTRATION – Engineers for: production, planning, purchasing, cost analysis, etc. Write W. D. Coursey.

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For Switchgear and Engine Starting, where High Discharge is necessary without damaging the Plates and no extreme loss of voltage—NIFE Batteries are beyond compare. Cycling determines the long life expectancy. The number of Trippings, Closings or Starts and ability to carry the connected load in an emergency determines the quality of a Battery. Other alleged long life batteries, imitating ours, have failed in this type of service over a period of time. In performance

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In heat or cold a battery must be there with sure guaranteed power. It must be immune to excessive discharges and short circuits, not be ruined by freezing, have a low capacity drop at high discharge rates, generate no corrosive gases and be capable of accepting charge at low charging rates. You must investigate the ORIGINAL NICKEL CADMIUM BATTERY.

It is an investment—not a maintenance cost. NIFE Battery prices are not much more than your presently used batteries and when figured over expected life and your costs will be more than cut in half. You will discover

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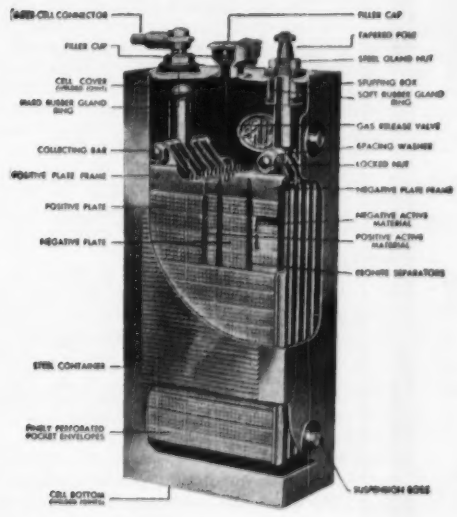

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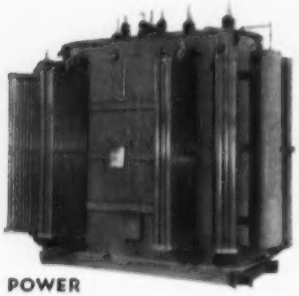
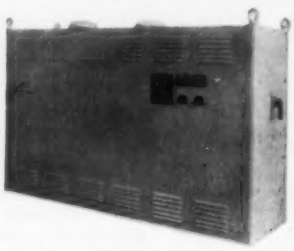


POWER

Standard builds in sizes to 10,000 KVA and incorporates any special features required.



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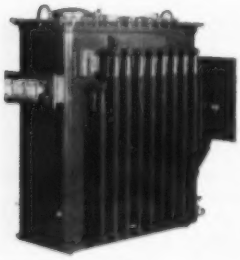
Sizes up to 1,000 KVA and maximum voltage ratings of 4,800.



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(Continued from page 18A)

Industrial Notes

Arizona Plant. The Sperry Phoenix Company, Division of Sperry Rand Corporation, has opened the doors of its new, permanent home in Arizona. The specially designed Arizona facility is expected to add greatly to Sperry's ability to produce advanced electronic aviation equipment rapidly and at lower cost. It also will enable the company to expand its engineering and production services to the large aircraft industry on the West Coast. For further information contact Sperry Rand Corporation, 30 Rockefeller Plaza, New York 20, N.Y.

Avion Division of ACF. Avion Division of ACF Industries, Incorporated, has completed consolidation of its New Jersey headquarters facilities with the occupancy of a third building in the Paramus Industrial Park, on Park Place just off Route 17. The move brings together in the new building the following elements: the coil-winding and assembly groups, the component test group, the maintenance shop, the environmental test group, and the components engineering group.

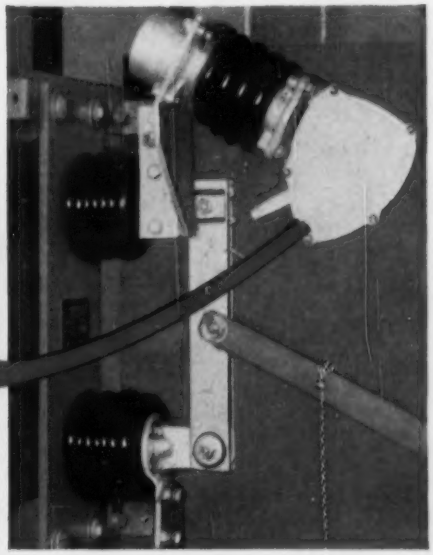
West Coast Fabricating Plant. A plant to serve the 11-western states area, has been placed in operation in Los Angeles, Calif., by National Vulcanized Fibre Company. Equipped to fabricate all the company's plastics, including laminates, nylon, and vulcanized fiber, the new facility will increase the company's overall fabricating capacity by more than 10%. Other fabricating plants are located at Maryland Ave. and Beech St., in the company's headquarters city of Wilmington, Del., and in Chicago, Ill., Johnson City, N.Y., and Toronto, Ont., Canada. In addition to the fabricating operation, the new facility, which the company is occupying on a lease basis is also serving as a central warehouse and as the Los Angeles district office.

Mobile Exhibit. Fischer & Porter Company, 235 Warminster Rd., Hatboro, Pa., manufacturer of industrial instrumentation systems, data reduction and automation systems, chlorination equipment, and industrial glass products, is sending a mobile exhibit of its products throughout the United States. The exhibit is housed in a specially constructed stainless steel trailer, completely equipped to give on-the-spot operating demonstrations of dozens of the company's products before customer groups, technical schools and universities, and at meetings of engineering societies.

Ohmite Plant Addition. A sizable addition to the Ohmite Manufacturing Company's plant, 3601 Howard St., Skokie, Ill., will increase manufacturing facilities by 42,000 square feet. The expansion is the third in 15 years for this company. The increased space provided by the addition will be used for expanding production and for manufacturing new products recently developed by the company.

(Continued on page 34A)

Now...Safe, positive interruptions for cubicles and unit type substations



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Breaks rated load instantly and decisively...eliminates danger to men and equipment through accidental operation!

The Delta-Star Powerupter combines an improved interrupting device with the most modern of disconnecting switches and an exclusive automatic trip mechanism that makes or breaks instantly and decisively.

Powerupter is ideal for use in small enclosed spaces because there is no danger of phase-to-phase or phase-to-ground faults AND NO EXTERNAL ARC. For the same reason, there is no danger to men or equipment if the unit is accidentally operated.

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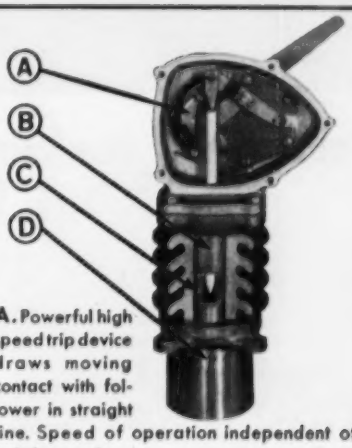

A. Powerful high speed trip device draws moving contact with follower in straight line. Speed of operation independent of switch speed.

B. Arcing chamber lined with gas evolving material encloses both stationary and moving contacts.

C. Follower of gas-evolving material, drawn up into arcing chamber to insure rapid extinction for all current values.

D. Exhaust chamber muffler confines and cools exhaust gases released from interrupting chamber.

H. K. PORTER COMPANY, INC.

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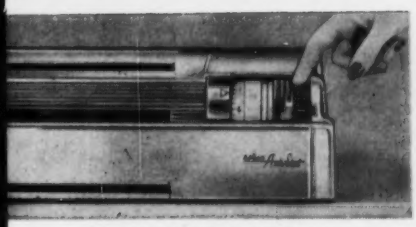

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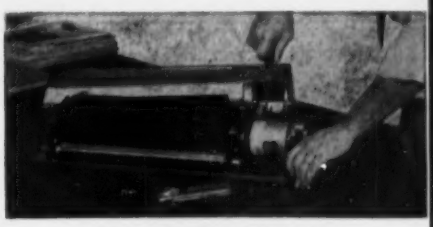

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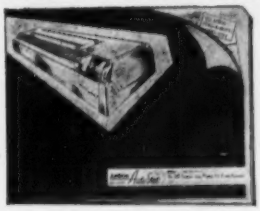

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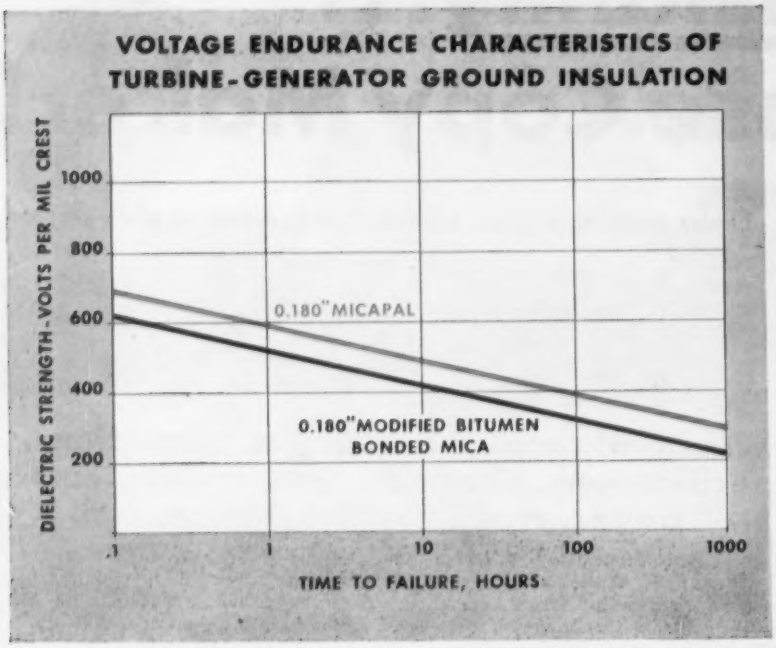
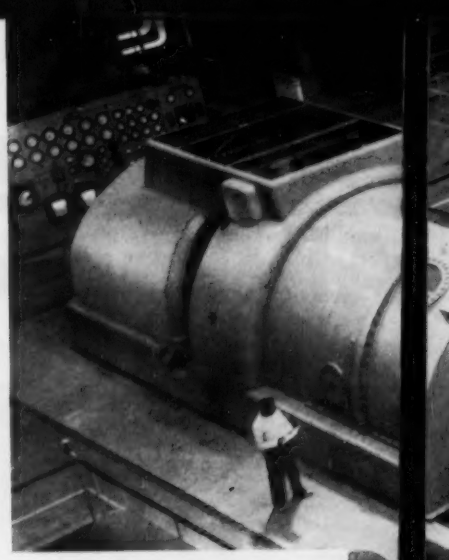
In Canada: Apeco of Canada Ltd., 134 Park Lawn Rd., Toronto, Ont.
In Mexico: Apeco de Mexico, S. A., Mexico City

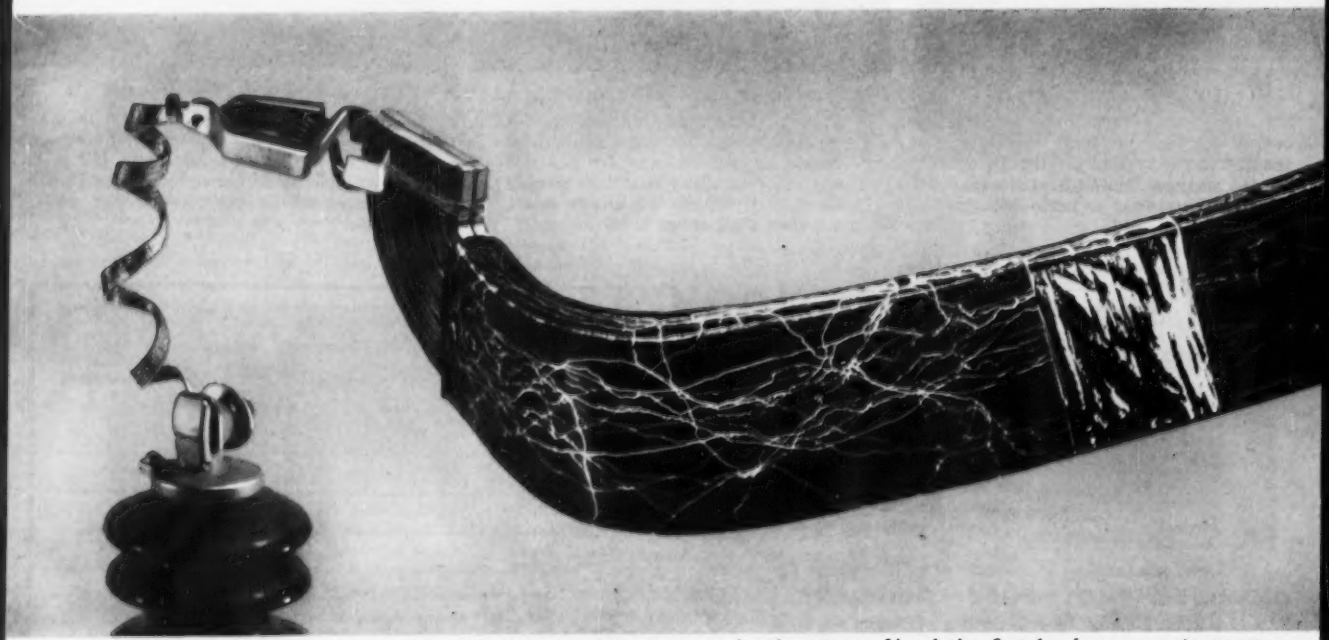


SIGNIFICANT IMPROVEMENT is noted in voltage endurance obtained for any duration of voltage application on Micapal compared to presently accepted generator insulating material. This improved voltage endurance increases long-term turbine-generator availability.

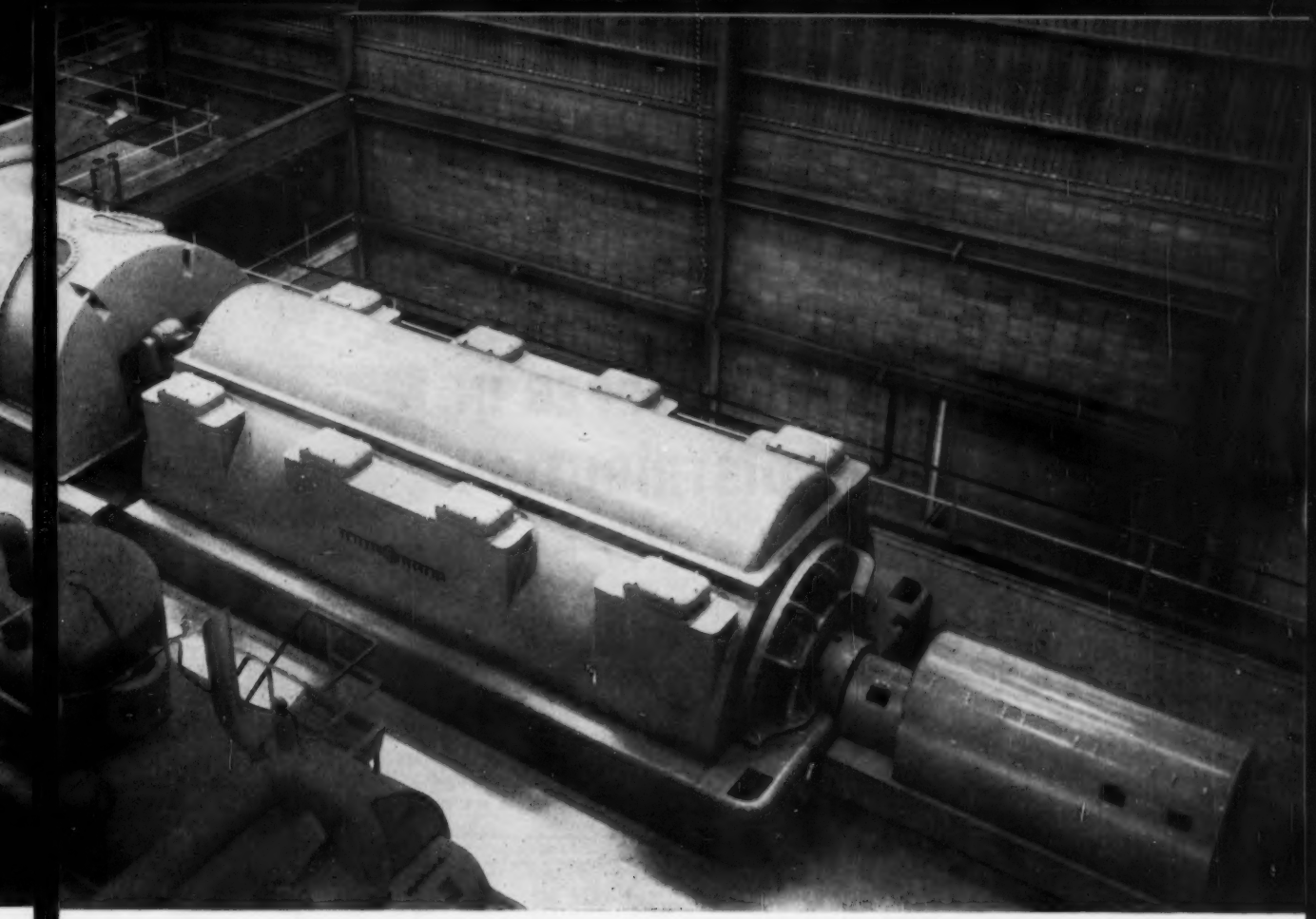


MICAPAL INSULATION better withstands high voltages and variable stresses caused by differential thermal expansion and contraction in large generator stator windings. Micapal is used on this 183,824-kva generator installed at Pacific Gas and Electric's Morro Bay Station.

How General Electric Micapal i



INSULATION TESTS such as pictured here are used to compare the dielectric breakdown of different insulations. Forced to carry voltages far above their rating, test bars of various types of insulation first develop corona streamers, then finally fail, enabling engineers to measure the insulation's actual voltage endurance.



insulation extends generator life

IMPROVED INSULATION BETTER WITHSTANDS HIGH VOLTAGES, VARIABLE STRESSES

Now, after extensive research and four years of operating experience, General Electric announces the extended application of Micapal insulation for high-voltage stator windings. A major advance in providing still longer, more reliable operation, this mica-based insulation offers these distinct advantages:

Greater Tensile Strength. Micapal incorporates mica mat and some mica flake bonded with a duplex thermosetting resin. Mica mat is finely divided, reconstituted mica formed into sheets. The thermosetting binder, combined with uniform mica structure, makes Micapal much tougher at operating temperatures than earlier insulations.

Greater Dimensional Stability. Micapal is molded to the precise shape of generator armature bars. Because of thermosetting qualities, the insulation won't flow or lose shape. It possesses great mechanical strength over the full range of operating temperatures.

Improved Thermal Conductivity. Micapal removes heat from electrical conductors more easily. The result is that for a given current and same insulation thickness, the armature bar runs cooler.

Improved Dielectric Breakdown Strength. The voltage endurance characteristics shown on the chart, above, illustrate how Micapal insulation withstands a much higher voltage than other mica insulation for any given period of time. The impulse puncture structure of Micapal has been shown by laboratory tests to be higher by an even greater factor.

Improved Micapal insulation is just another example of General Electric steam turbine-generator progress in meeting tomorrow's power demands. For more information on new generator developments, write Large Steam Turbine-Generator Department, General Electric Company, Schenectady 5, New York.

254-41

Progress Is Our Most Important Product

GENERAL ELECTRIC

ENGINEERING MEMO FROM KAISER KW 4.2

A KW CONTRIBUTION TO THE INDUSTRY: It has always been our policy to contribute useful information to the electric industry. This article contains information which may prove helpful to utilities in their future operations. The article is in two parts: Part 4.1 dealt with bare secondaries; Part 4.2 deals with weatherproof. Reprints available on request.

ALUMINUM AND COPPER IN SECONDARY DISTRIBUTION

BY NEIL BARR
CHIEF ENGINEER
ELECTRICAL CONDUCTOR DIVISION

In rural areas—where spacing line to line is no problem, where joint use of pole does not ordinarily enter the picture, and where there are ample clearances to rights-of-way, buildings, and trees—bare wire for secondaries would probably be a reasonable choice. However, the major portion of secondary wire installed is in urban areas.

Many people will disagree about the advantages and disadvantages in urban areas of bare secondary conductors. Below are some points that should be considered in choosing between bare and weatherproof conductors for this use.

1. Secondary systems are designed to have a limited voltage drop both under steady state conditions and flicker resulting from frequent starting of small motors. If bare secondaries are used, the first assumption to make is that the spacing, whether horizontal or vertical, will be increased, which in turn increases the reactive voltage drop and has an adverse effect on both steady state and flicker voltage drop.

2. The assumption that the spacing will be increased is based on service reliability. Bare conductors too closely spaced will be subjected to danger of line outage due to either a strike of one wire against another or contact with some foreign object between two wires. It is logical to make this assumption, since there is a minimum requirement for service continuity and reliability.

3. The ASA specification for neoprene type weatherproof ACSR permits a maximum reduction in breaking strength after covering of 5 per cent. This slight reduction in strength plus the added weight of covering material does necessitate increased sag in a given span. Since span lengths usually are dependent upon the width of home lots, which control pole locations for convenient service take-offs, it is seldom necessary to use the maximum span possibilities of a given conductor.

4. If bare conductor is used rather than W.P. covered conductor, there is a possibility of longer spans for a given maximum tension, pole size, and ground clearance, but very rarely in distribution is this the governing condition for pole locations since they must be located for convenient service take-offs.

Part of the increased material cost of W.P. conductor over the cost of bare conductor may be offset by the reduction (but not elimination) of tree trimming cost to insure service continuity or reliability mentioned under (2) above.

Although dielectric properties are not ordinarily evaluated when W.P. conductor is considered, there is little doubt that the coverings in use today eliminate a great many service interruptions due to either tree limb contacts or momentary strikes.

MAXIMUM SPAN—FEET
HEAVY LOADING DISTRICT
MAXIMUM STRESS LIMITED TO 50% OF THE BREAKING STRENGTH

Maximum Permissible Sag		Size and Type Conductor			
		#6 AWG Copper	#4-6/1 ACSR	#2 AWG Copper	#1/0-6/1 ACSR
Sag – ft.	Temp. – °F	TBWP	Neo.	TBWP	Neo.
2	60	119	157	172	195
2	120	108	148	145	150
3	60	136	192	205	250
3	120	128	160	175	195

TABLE I

Aluminum Weatherproof vs. Copper Weatherproof

From the discussion in Engineering Memo 4.1, previously issued, it may be concluded that weatherproof conductors are more reliable, conform with the requirements of many city or village ordinances, are electrically a compromise between spacing of bare conductor and cable construction when considering voltage drop, and probably should be established as the base construction when considering the relative economics of bare, weatherproof, or cabled secondaries.

It is not intended here to expand the discussion of weatherproof conductor to include the relative merits or demerits of coverings. Suffice it to say that either polyethylene or neoprene coverings strip more cleanly and easily from aluminum stranded conductor than type URC triple braid weatherproof. Either of these homogeneous coverings on copper is more costly than TBWP, and therefore, the discussion will be limited to either polyethylene or neoprene covered aluminum as compared to TBWP copper.

It has already been established that from the standpoint of fusing current, aluminum is an acceptable alternate for copper conductor. For this reason, there is no need for greater separation between aluminum wires as compared to copper.

The second consideration is span length. Since in the heavy loading district smaller sizes of all aluminum do not have the proper strength to satisfy sag requirements, we will only compare ACSR and copper.

From Table I it is again evident that if ACSR is used, span lengths can be longer than that permissible with copper. Neoprene has been chosen since it is heavier than polyethylene and will result in shorter spans. By the same token, since the sag information presented above shows that longer spans are permissible for ACSR, it is not likely that they will be used. Span lengths ordinarily are dependent upon poles located for service drops.

ESTIMATING COST—PER 1000 FT. OF CONDUCTOR*						
	TBWP #6 solid HD Cu.	Neo. #4-6/1 ACSR	TBWP #4 solid HD Cu.	Neo. #2-6/1 ACSR	TBWP #2-7 HD Cu.	Neo. #1/0-6/1 ACSR
Cost per 1000 ft.	$60.57	$43.50	$ 87.71	$59.00	$146.15	$ 95.00
Cost of copper dead end	5.22	—	5.48	—	8.32	—
Cost of ACSR dead end (loop)	—	6.00	—	8.70	—	8.70
Electrical taps (4/pole)	7.68	12.96	9.60	14.40	14.40	32.64
TOTAL COST/1000 ft.	$73.47	$62.46	$102.79	$82.10	$168.87	$136.34
Per cent conductor savings	—	28.2%	—	32.7%	—	35.0%
Per cent material savings	—	15.0%	—	20.1%	—	19.3%

* Based on 150 ft. spans

TABLE II

In Table I, one may note that in all cases, ACSR is a satisfactory alternate for copper; strength is superior to hard drawn copper; resistance, which is the basis for comparison, is approximately the same as copper; the weight without ice and wind is less, and with ice and wind is approximately equal due to the greater weight of ice on the larger diameter conductor.

Economics of ACSR vs. Copper

Prices in effect { 2/21/56—Cu; 3/26/56—Al

If we consider again that the cost may be broken into fixed and operating costs, we will only have to deal with the fixed costs, since the operating cost of equivalent size conductors will be approximately the same. The fixed costs will be considered to be mainly first cost.

The comparison in Table II is on the conservative side, since it is assumed that even on #2 copper, a wrapped dead end will be used while ACSR will require loop-type dead end clamps. This is evident when it is noted that although there is appreciable conductor savings, the % material savings is reduced by using both mechanical dead ends and aluminum electrical taps.

It has been assumed that cost of poles, crossarms, racks, insulators, tie wire and anchors will cost the same regardless whether aluminum or copper is used.

Conclusions:

Aluminum (ACSR) can be used economically in secondary distribution as a replacement for copper since:

1. There is no reason to either increase conductor spacing or decrease pole separation.
2. The physical characteristics of ACSR, enabling it to withstand ice and wind loading, are superior to equivalent copper characteristics.
3. The electrical operating and maintenance charges for ACSR should be no more than for copper.
4. Considering first cost only, there is an appreciable saving with ACSR conductor as shown above.
5. The total material savings may shrink to approximately 5% for #6 copper equivalent, but also may be as high as 15%. This figure is conservative, since only copper conductor and taps were considered. Mechanical dead ends were considered for aluminum.

General

The comparisons of copper and aluminum conductor made in Engineering Memos 4.1 and 4.2 on both bare and weatherproof were only on secondaries. Similar savings would be reflected in the primary and, in fact, might show a large saving in favor of aluminum, since fewer taps would be considered. Certainly, if aluminum is "proved in" for secondaries, it will also be more economical for primaries.

During the electric power industry's rapid expansion, Kaiser Aluminum has concentrated intensively on utility problems—with special emphasis on covered wire.

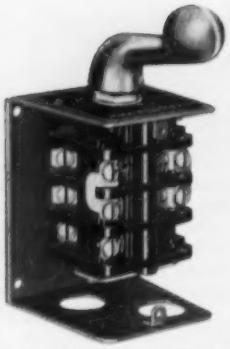
Today, Kaiser Aluminum is the nation's fastest growing producer of aluminum wire and cable, making available the latest helpful information on modern products and practices.

A KW representative or a KW distributor will be glad to give you immediate attention. Call your Kaiser Aluminum sales office. Kaiser Aluminum & Chemical Sales, Inc., *Executive Office*, Kaiser Bldg., Oakland 12, Calif.; *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois.

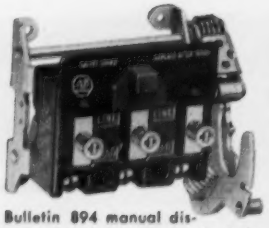
PHYSICAL CHARACTERISTICS OF WEATHERPROOF CONDUCTOR						
	#6 HD Copper TBWP	#4-6/1 ACSR Neo.	#4 HD Copper TBWP	#2-6/1 ACSR Neo.	#2 HD Copper TBWP	#1/0-6/1 ACSR Neo.
SOLID CONDUCTOR						
Outside diam. (in.)	0.287	—	0.329	—	0.414	—
Min. HD copper Strength (lbs.)	1215	—	1870	—	2850	—
D-C resistance, ohms/1000 ft. (20°C)	0.4108	—	0.2584	—	0.1625	—
Weight, lbs./1000 ft.	112	—	164	—	260	—
STRANDED CONDUCTOR						
Outside diam. (in.)	0.309	0.344	0.357	0.409	0.448	0.523
Strength (lbs.)	1165	1740	1840	2650	2894	4070
D-C resistance, ohms/1000 ft. (20°C)	0.4191	0.4137	0.2636	0.2602	0.1658	0.1635
A-C resistance, ohms/1000 ft. (50°C)	0.453	0.487	0.285	0.320	0.183	0.212
Wt., lbs./1000', bare	115	94	170	139	270	224
Bare + ½" ice + 4 lbs. wind + K	1082	1074	1164	1156	1339	1347
Wind load on conductor lbs./1000 ft.	445	448	463	469	503	518
Approx. current capacity wind 2 ft./sec.	115	125	155	160	210	215

Kaiser Aluminum

IF IT CARRIES CURRENT KW CARRIES IT!



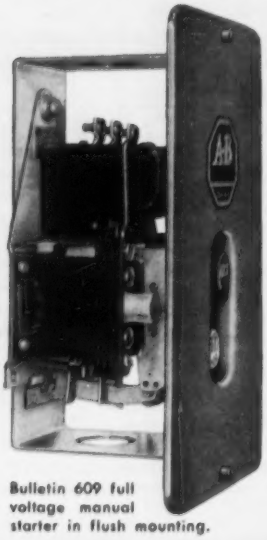
Bulletin 806 pilot drum switch—10 ampere size—with cover removed to show terminals.



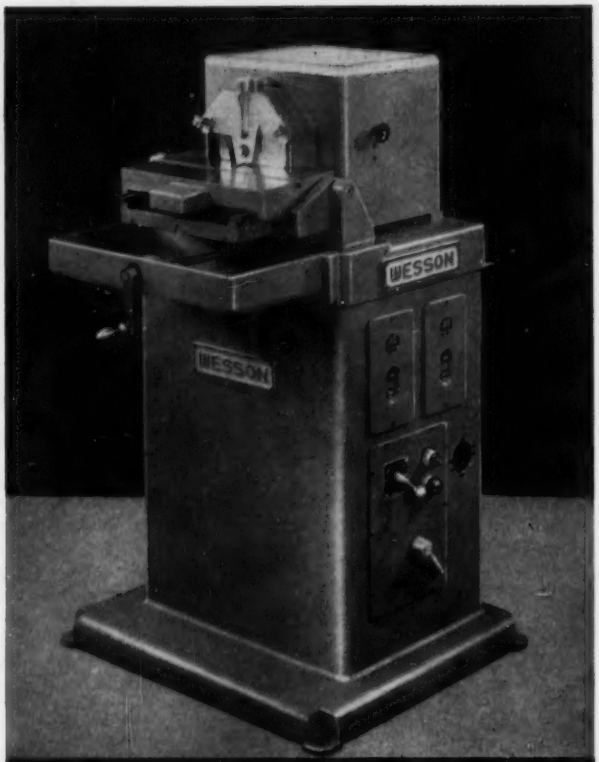
Bulletin 894 manual disconnect switch in base of grinder.

Bulletin 800T oiltight selector switch for Hand-Off-Auto control.

Bulletin 800T transformer type pilot light—550 volts, maximum.



Bulletin 609 full voltage manual starter in flush mounting.



Wesson Poweramic Tool Grinder with A-B manual motor controls for 3 motors.

Close-up of control panel of Wesson Poweramic Tool Grinder with flush type motor controls.

Streamline your motorized machines with Allen-Bradley flush type controls

By using flush type control units, the Wesson design engineer not only succeeded in grouping the controls for the three motors within easy reach of the operator, but in streamlining this Poweramic tool grinder, he gave it added sales appeal.

The flush mounted manual starters fit into recesses just above the flush mounted drum switch. The manual disconnect switch near the bottom of the machine base controls the power supply of the entire machine.

Flush type control equipment provides a wonderful opportunity for designing compact, good-looking machines. Follow this modern trend—and increase your sales. Let us send you our latest Handy Catalog giving full data on the Allen-Bradley line. Write, today.

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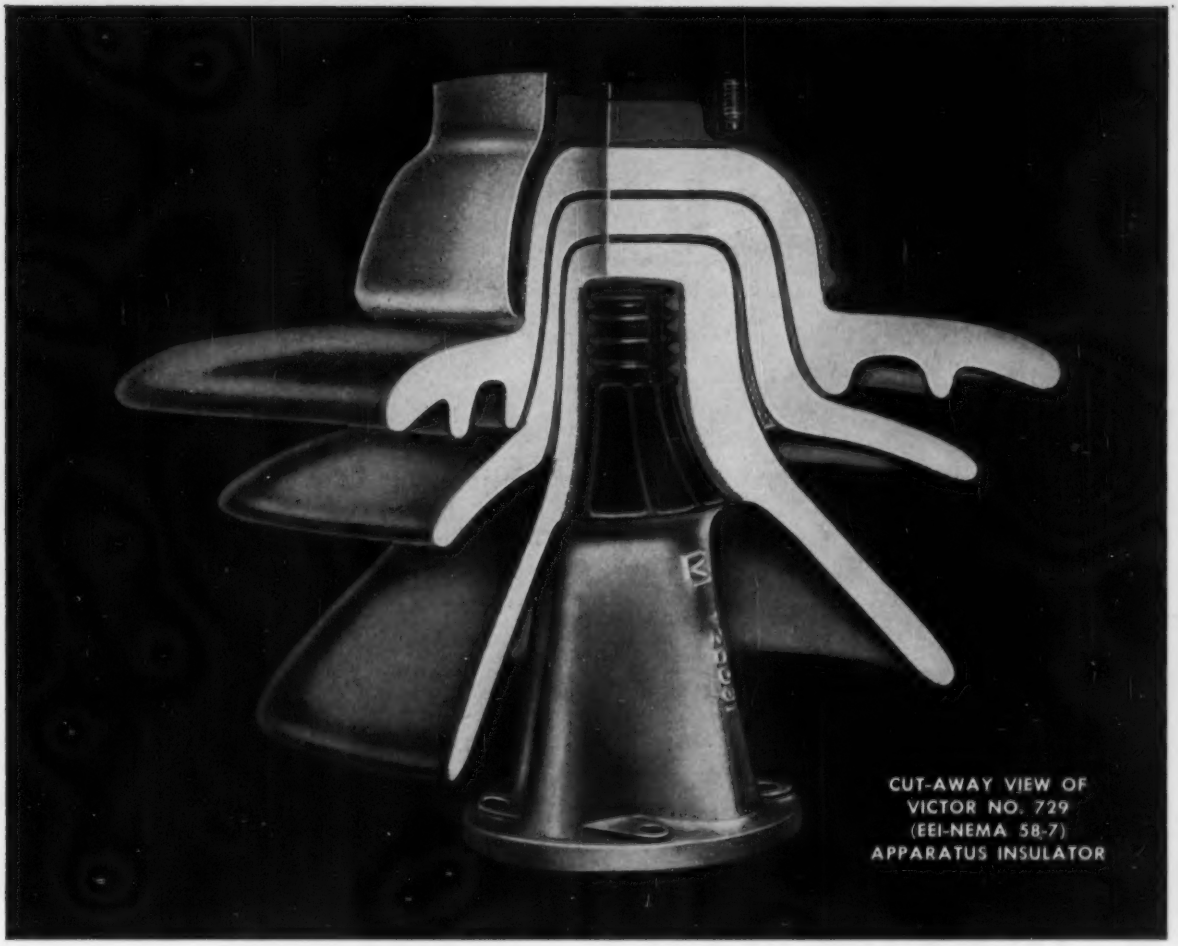
ALLEN-BRADLEY
SOLENOID MOTOR CONTROL
QUALITY



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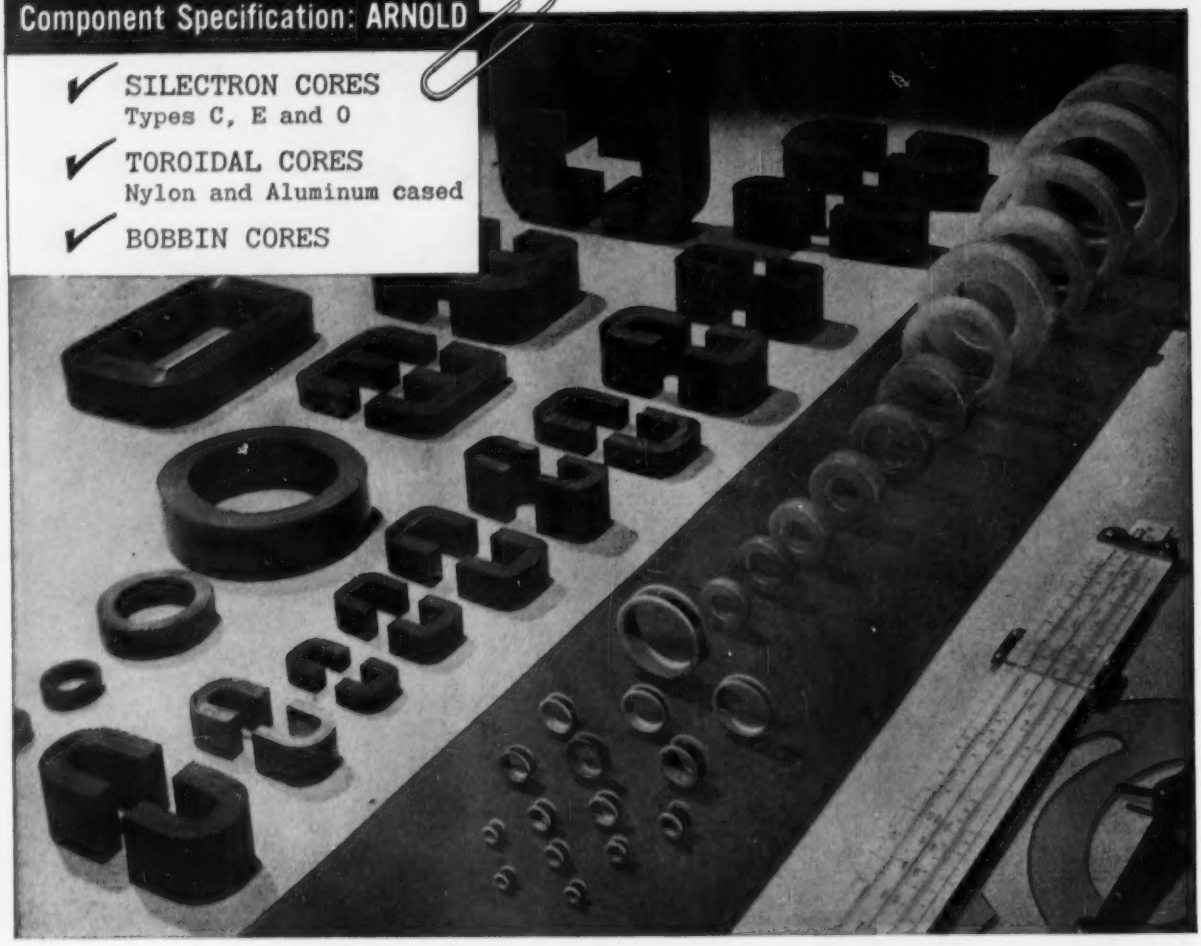
  Types C, E and O
- ✔ TOROIDAL CORES
  Nylon and Aluminum cased
- ✔ BOBBIN CORES



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TC-107—*Silectron Cores, Types C, E and O*
TC-101A—*Toroidal Cores, nylon and aluminum cased*
TC-108A—*Bobbin Cores*

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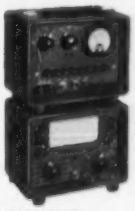
MODEL 10A, A-C ELECTRONIC VOLTMETER
Self-contained battery power. All-transistor circuitry on printed wiring. Unique sensitivity and stability are ideal for field or bench testing of modern communication and data-handling equipment. Measures voltages from 1 mv full-scale to 300 volts full-scale. Frequency range from 20 cycles to 500 kilocycles. Size 6"x8"x6¼"; weighs only 5 lbs. Trouble-free operation. Competitively priced.



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TEST OSCILLATOR (TELECOMMUNICATIONS)
8 preset frequencies (pushbutton)
Balanced output—600 ohms impedance

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MULTI-RANGE A-C VOLTMETER
Balanced input—30 cps to 300 kc
1 mv to 300 v full-scale

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0.5 mv full-scale
Response: 10 cps to 500 kc

MODEL 20A
TEST OSCILLATOR
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For bridging 600-ohm circuits
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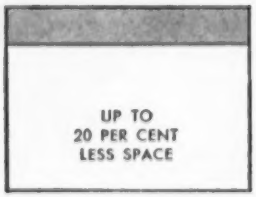
. . . handles up to 90 percent more inrush current than Hevi-Duty Type SIO transformers — the previous performance leaders — and up to 150 percent more than transformers without interleaved windings.

In this much less panel space



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(Continued from page 22A)

Industrial Notes

New Location. The ElectroData Division of Burroughs Corporation has announced a new location for its Los Angeles district office at 230 N. Lake Ave., Pasadena, Calif. More than 50 sales and field engineers are headquartered there. ElectroData's main plant is located at 460 Sierra Madre Villa, Pasadena, Calif.

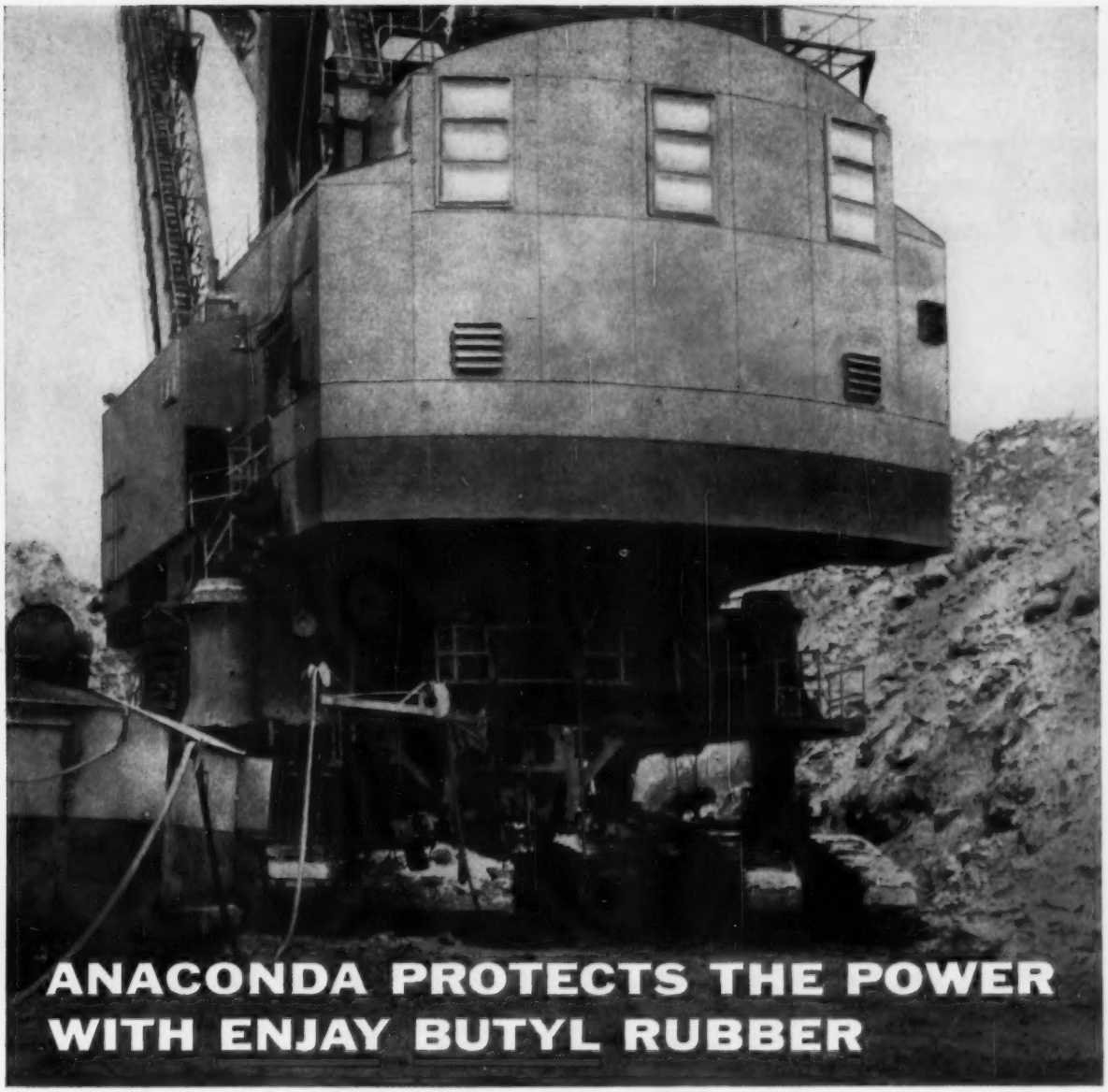
Smallest Atom Sub Instruments. Automatic control instruments, designed, developed, and manufactured by the Marine Division of the Sperry Gyroscope Company, Great Neck, N.Y., increase and advance the underwater operating efficiency of the newest and smallest atom-powered submarine *Skate*. *Skate* is equipped with new split-rudders that pivot, and with Sperry's automatic course-keeping system to increase the submarine's maneuverability.

Robertshaw-Fulton Move. The executive offices of Robertshaw-Fulton Controls Company, now at Greensburg, Pa., will be relocated in Richmond, Va. Reasons are the need to maintain closer liaison with Government agencies and departments; a generally better geographic location with respect to the company's manufacturing divisions at Milford, Conn., Philadelphia, Pa., Knoxville, Tenn., and other points in the East; and the fact that Richmond offers good air transportation facilities for company personnel.

Automatic Seamless Steel Tube Mill. Manufacture of seamless steel tubing became completely automatic when Mannesmann Tube Company, Ltd., opened their new mill in Sault Ste. Marie, Ontario, Canada. The entire mechanization process serves as an introduction to industrial automation. In the initial step of the push-button operation, round steel bars, or billets, are transported in 25-ton lots by Ross straddle carriers from the Algoma Steel plant, less than a quarter of a mile away. Oxygen-electric torches cut the billets to their proper length. The rated capacity of the new mill will be approximately 225,000 tons annually of oil field American Petroleum Institute-approved pipe, including 125,000 tons of threaded pipe. A further stage will be the addition of a tubing mill.

Gulton Industries. Acquisition of CG Electronics Corporation, Albuquerque, N.M., by Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J., has been announced. The company will retain its corporate identity, operating as the CG Electronics Corporation, a wholly owned subsidiary of Gulton Industries, Inc. Radio control and telemetry equipment will be continued in the company's production with the anticipated production of instrumentation for powered rockets and mist distance indicators in the near future.

(Continued on page 42A)



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Talk about impact resistance! The 5-year-old Anaconda cable supplying this giant shovel with power was buried under thousands of tons of rock when a whole wall of the open pit mine caved in . . . *yet the cable continued to supply power!* This is one of the many Anaconda products featuring Enjay Butyl for *outstanding* performance.

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- New, More Flexible Tape Units
- Single-Instruction Square Root
- Divides and Multiplies Simultaneously
- No De-bugging Run Necessary
- Develops 30-Digit Product
- Fifteen-Digit Input and Output

TECHNIQUES RIGHT AT YOUR FINGER TIPS

UNCES THE

COMPUTER

- Cathode Ray Tube Display
- Decimal or Octal Arithmetic
- High-Speed Printed Numerical Output
- No Special Air Conditioning Needed
- Low Cost

For the engineer and scientist, with a minimum of instruction, the compact new IBM 610 Auto-Point Computer provides large-scale electronic computer facilities at desk-side.

"TIME EQUIPMENT"
DATA PROCESSING
ELECTRIC TYPEWRITERS
MILITARY PRODUCTS

IBM® TIME EQUIPMENT

"Alcoa" starts with this...

to make

Long-lived, lightweight service drop

Right from the start, "Alcoa" triplex service drop is engineered for easy installation and low maintenance. Its two conductors have an extruded covering of BAKELITE Brand Polyethylene.

This is a uniform, lightweight, weather-resistant covering. It is tough and flexible, and will not festoon. It permits longer spans, faster stripping and splicing, easier handling.

BAKELITE Polyethylene provides the same advantages when used on line wire and control cable. It is top-quality material, formulated specifically for these jobs by the company with the longest experience in plastics. For technical data on BAKELITE Brand Polyethylene and names of wire manufacturers who use it, write Dept. ZO-55.

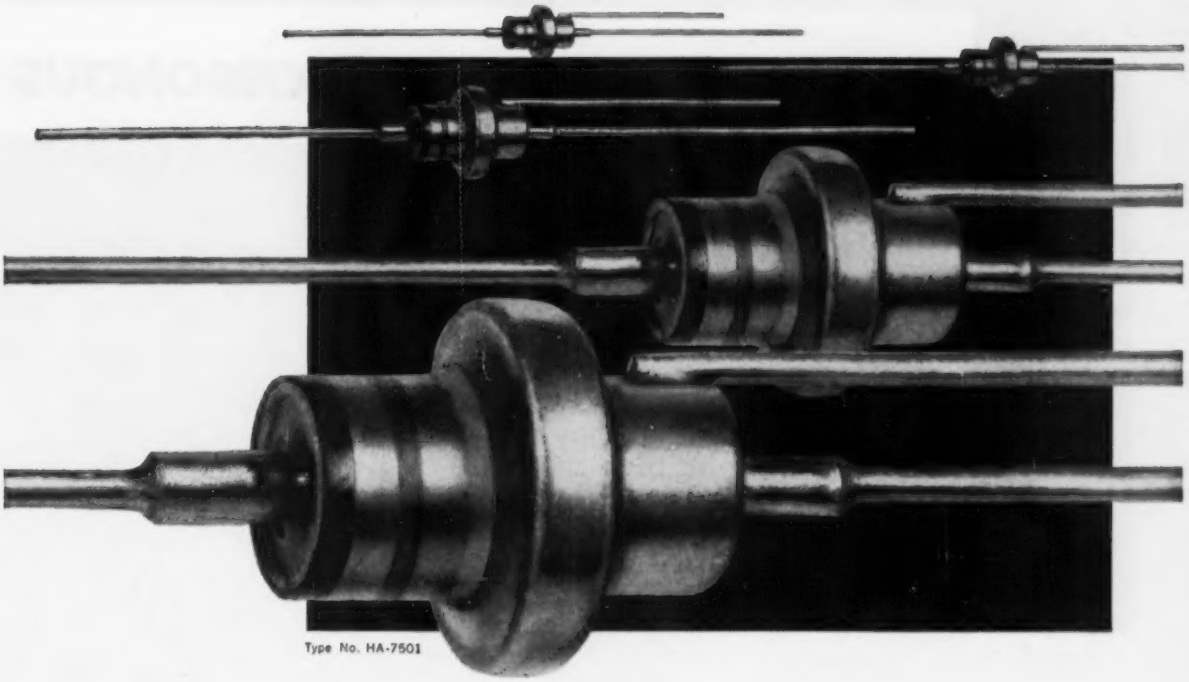
BAKELITE
BRAND
PLASTICS

UNION CARBIDE

Photos courtesy of Aluminum Company of America, Pittsburgh, Pa.

BAKELITE COMPANY, *Division of Union Carbide Corporation,* 30 East 42nd Street, New York 17, N. Y.

The terms BAKELITE, UNION CARBIDE and the Trefoil Symbol are registered trade-marks of UCC.

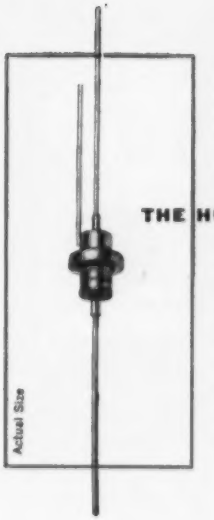


Type No. HA-7501

here today!

SILICON TRANSISTORS by HUGHES

now in production quantities



Hughes offers a "high temperature" transistor, an alloy-junction PNP device for audio, switching, and control circuitry at medium power levels—and at junction temperatures as high as 150°C. Outstanding characteristics: power dissipation in free air at 25°C, 500mW...saturation resistance at 100mA collector current, 10 ohms...voltage for the common emitter connection, 50V maximum...and, in addition, high current capabilities coupled with low reverse saturation currents.

THE HUGHES PACKAGE

Here Hughes departs from the conventional to offer a transistor with coaxial leads. In contrast to the single-ended configuration, this unique design permits the maximum flow of heat from the crystal through the package while providing an extremely sturdy internal structure. Also, it permits rigid mounting (particularly on printed circuit boards), thereby increasing the ability of the equipment to withstand physical shock or vibration. Abetted by small size and a hermetic seal, this kind of ruggedness results in a package which is just about as practical as a package can be. Maximum dimensions: body length, .396 inch; body diameter, .343 inch.

Perhaps you saw our new transistor at the WESCON show and discussed it there. If not, and you wish additional information now, please write:

SEMICONDUCTOR DIVISION
HUGHES PRODUCTS
International Airport Station
Los Angeles 45, California

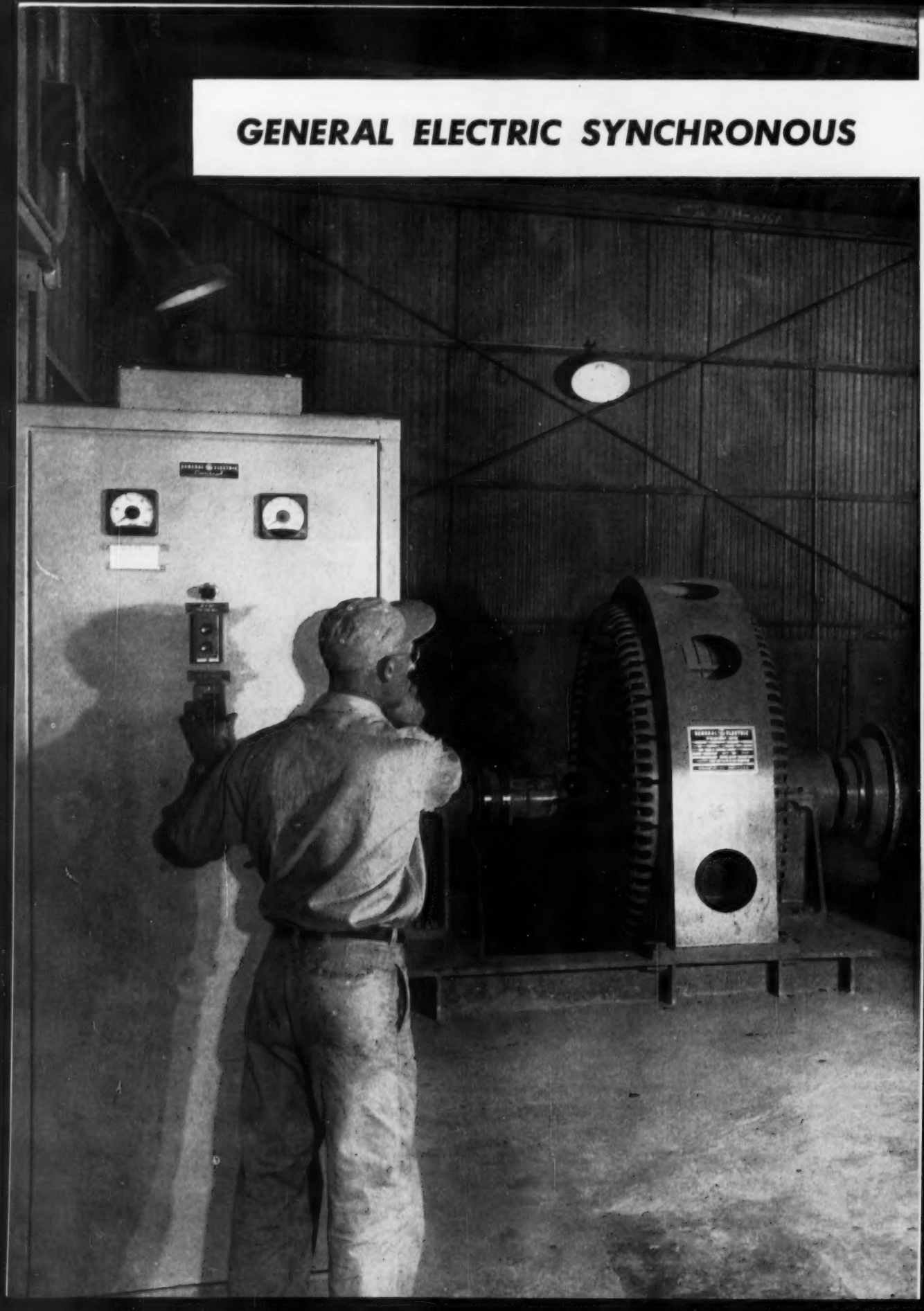
Creating a new world with ELECTRONICS

HUGHES
SEMICONDUCTORS

HUGHES PRODUCTS

© 1957; Hughes Aircraft Company

GENERAL ELECTRIC SYNCHRONOUS



MOTOR CONTROL ASSURES

Maximum drive protection through "split-second" field removal

General Electric controls provide the fastest field removal—the most protection—available for synchronous motors and attached equipment. General Electric's "split-second" field-removal system removes the field excitation in approximately 1/120 of a second: technically, within one-half-slip cycle.

This field-removal system virtually eliminates the possibility of damage to synchronous motor drives that results from the motor pulling out-of-step. In the event of excessive torque, or fluctuations in line and excitation voltages, the control immediately removes the field excitation. This prevents damage to motor windings, to connected machinery, and to the distribution system, caused by the motor running out of synchronism with the field applied.

CONSTANT PROTECTION

G-E synchronous motor control provides constant protection from the time the start-button is pushed until the motor is de-energized. A graduated protection system prevents motor damage from overheating while starting but allows full utilization of the motor during acceleration. This system is controlled by the heating characteristics of the motor and not by a set time period.

MAXIMUM MOTOR UTILIZATION

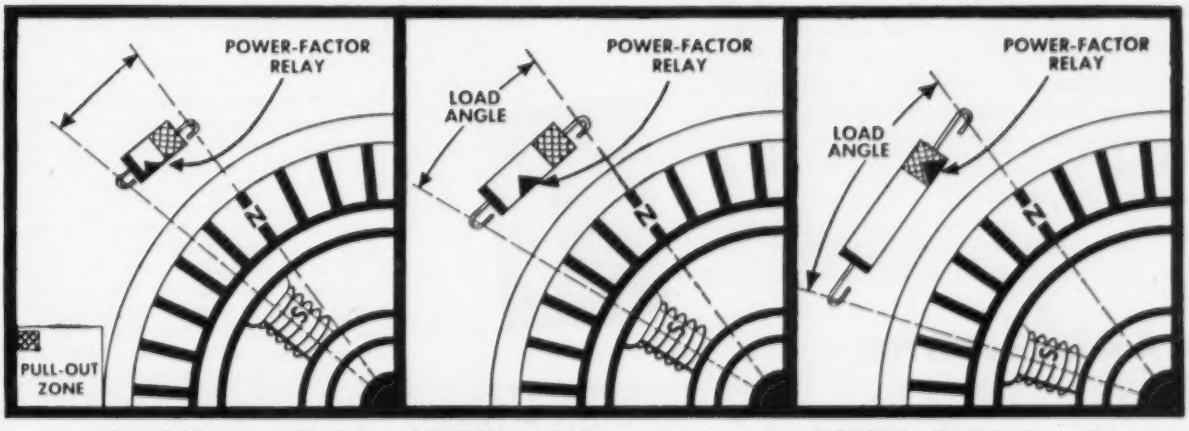
Your motor will deliver the power it was designed to produce as a result of the G-E precision field application system. The field is applied at exactly the right instant—assuring positive synchronization on the first attempt. In addition, the harmful effects of repeated slipping of poles and resulting motor stress are eliminated.

Assure maximum protection and utilization of your synchronous motor . . . specify the control that gives you all the "extras" as standard equipment: General Electric synchronous motor control. For more information, write for GEA-5873B, to Section 783-6, General Electric Co., Schenectady, N. Y., or contact your nearest G-E Apparatus Sales Office.

Industry Control Department, Roanoke, Virginia

GENERAL ELECTRIC

FASTEST FIELD REMOVAL AVAILABLE

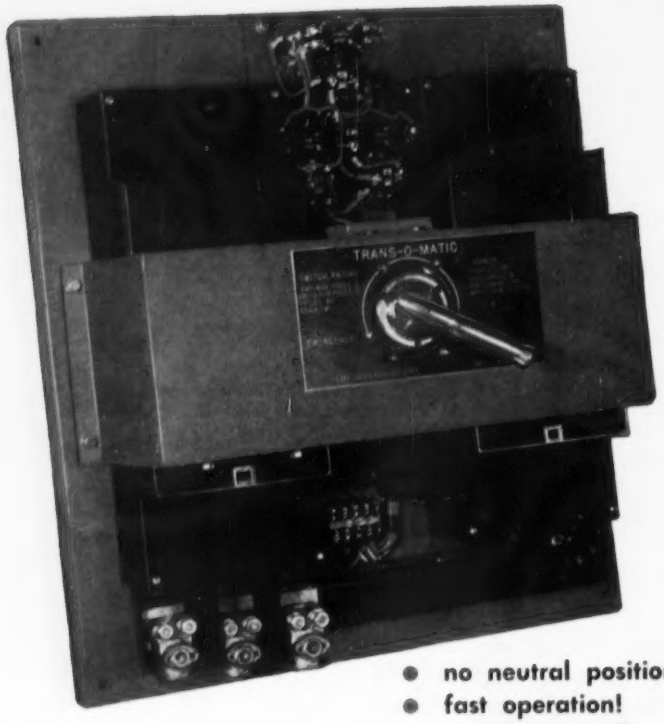


DURING NORMAL OPERATION, the load angle is constantly measured by power-factor relay.

ADDITIONAL LOAD on motor increases load angle. Relay will not remove field if flux is sufficient to hold motor in step.

EXCESSIVE OVERLOAD, sufficient to cause out-of-step operation widens load angle, causes control to remove field.

TRANS-O-MATIC WORKS



- no neutral position!
- fast operation!
- total or partial failure protection!

This failure-proof transfer switch employs two mechanically-linked molded case circuit breakers for positive transfer to emergency source. Full relay protection on transfer, with power taken from side to which the load is transferred. Available in sizes to 600 volts, 800 amps, and 50,000 amp interrupting capacity.

Request Trans-o-matic Automatic Transfer Switch Bulletin TS-56 for details.

LAKE SHORE
Electric CORPORATION
207 WILLIS AVENUE
BEDFORD, OHIO

(Continued from page 34A)

NEW PRODUCTS

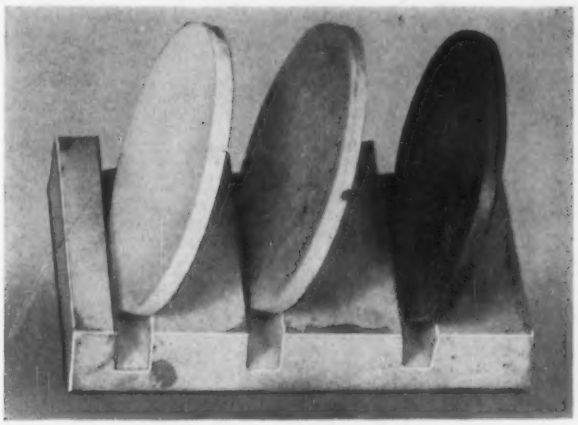
Sub-subminiature Tantalum Capacitors. Two new sizes have been added to the Ohmite Tan-O-Mite (*registered trademark*) line of Series *TW* (tantalum wire) electrolytic capacitors. Designated sizes "S" and "T," the new units constitute the smallest units of this type available. Size "S" case dimensions, for example, are $\frac{3}{16}$ inch length by $\frac{5}{64}$ inch diameter; size "T," even smaller, measures $\frac{5}{32}$ inch length by $\frac{5}{64}$ inch diameter. They are noted for their exceedingly long shelf life and electrical stability and are increasingly being adopted for use at low d-c voltage in transistorized and miniaturized equipment—hearing aids and military apparatus. For additional information write for Bulletin *148B*, Ohmite Manufacturing Company, 3629 Howard St., Skokie, Ill.

Mobile Source Unit. The Model *LC-9* Mobile Source Unit consists of a source container with a cart especially designed to handle a heavy object with extreme ease and offer maximum protection to laboratory floors and thresholds. In addition to the rubber rimmed front wheels located at the center of gravity, this cart has two rear supporting casters, and provisions for varying the angle of the truck body. The 165-pound cast can be moved with ease by female laboratory personnel. For complete information, write to Technical Associates, 140 West Providencia Ave., Burbank, Calif.

Hi-Fi Tape Recorders. Highlighted in the 1958 line of phonographs, high-fidelity instruments, and tape recorders introduced by the Symphonic Radio and Electronic Corporation, 235 Jersey Ave., New Brunswick, N. J., were 9 phonographs, 3 radio-phonograph combinations, 10 high-fidelity instruments, and 5 tape-recorders. Features of the high-fidelity models, both tabletop and console, include jam-proof, 4-speed automatic, intermix record-changers; four speakers, in several instruments; three speakers, in others; 50-watt power output; frequency response of 20 to 20,000 cycles; and an input selector and compensator.

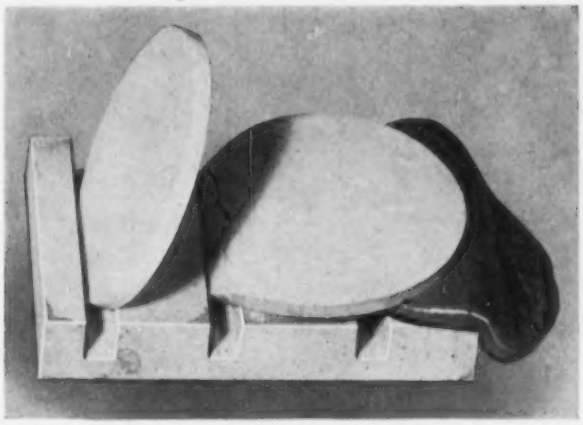
Voice for Electronic Brain. A voice data link system, which can convert automatic commands from computing machines into verbal messages, has been announced by the Electronics Division of Fairchild Controls Corporation, a wholly owned subsidiary of Fairchild Camera and Instrument Corporation, Robbins Lane, Syosset, L. I., N. Y. Virtually giving voice and vocabulary to an electronic brain, a wide variety of uses is seen for the device. Important applications are air traffic control, airborne early warning, remote voice communication, information directory in airline and railroad terminals, and multilingual communications.

(Continued on page 50A)



START OF TEMPERATURE TEST

SUPRAMICA* 560 ceramoplastic insulation (Left) is to be compared with SUPRAMICA* 555 ceramoplastic (Center) and MYCALEX 410* glass-bonded mica — the best available materials with comparable properties.



75 MINUTES AT 550° *PLUS* 15 MINUTES AT 650°C

SUPRAMICA 560 ceramoplastic still shows NO NOTICEABLE EFFECT — SUPRAMICA 555 has completely cracked through — MYCALEX 410 has foamed and collapsed.

SUPRAMICA* 560 ceramoplastic

INSULATION FOR CONTINUOUS OPERATION AT 500°C

LIGHTWEIGHT MATERIAL CAN BE MOLDED WITH FRAGILE INSERTS

SUPRAMICA 560 ceramoplastic will free your designs from many of the functional limitations imposed by conventional insulating materials. Manufactured exclusively by Mycalex Corporation of America, SUPRAMICA 560 has the electrical and physical properties to meet exacting high-temperature insulation specifications — **in applications where no other material can be used!**

Proof of this high temperature performance is shown by these unretouched photographs of an actual "slump" test (Above). The characteristics listed at the right demonstrate the versatility of SUPRAMICA 560 ceramoplastic.

Lighter in weight than any comparable material — specific gravity similar to that of aluminum or mineral-filled polyesters — SUPRAMICA 560 is the perfect insulation for relay bases, connectors, tube sockets and many other parts in high-temperature components.

MYCALEX CORPORATION OF AMERICA precision molds this revolutionary new material for your product needs. Send for complete information.

SPECIFICATIONS: SUPRAMICA 560 ceramoplastic

DISSIPATION FACTOR, 1 MEG.	0.003
DIELECTRIC CONSTANT, 1 MEG.	6.8
DIELECTRIC STRENGTH, VOLTS-MIL	400
LOSS FACTOR, 1 MEG.	0.020
VOLUME RESTIVITY, OHM-CM	10^{14}
SPECIFIC GRAVITY	2.8 (Comparable to Aluminum or Mineral-Filled Polyester)
SAFE OPERATING TEMP.	
CONTINUOUS	500°C
SHORT-TIME	600°C
WATER ABSORPTION	NIL
HARDNESS, ROCKWELL M	125
THERMAL EXPANSION	12.4×10^{-6} (Same as SAE 1010 Steel)
THERMAL CONDUCTIVITY, CAL-SQ. CM-SEC (°C/cm)	.0015
FLEXURAL STRENGTH, PSI	15,000
INSERTS	WILL ACCEPT ALL MOLDED-IN VARIETIES

MYCALEX
CORPORATION OF AMERICA

GENERAL OFFICES AND PLANT:
CLIFTON BOULEVARD
CLIFTON, NEW JERSEY

EXECUTIVE OFFICES:
30 ROCKEFELLER PLAZA
NEW YORK 20, NEW YORK

SALES OFFICES:
CHICAGO — DAYTON
LOS ANGELES — MIAMI
WASHINGTON

*SUPRAMICA, MYCALEX, and 410 are registered trade-marks of MYCALEX CORPORATION OF AMERICA.
555 is a trade-mark of the MYCALEX CORPORATION OF AMERICA.
SYNTHAMICA is a trade-mark of SYNTHETIC MICA CORPORATION, a subsidiary of MYCALEX CORPORATION OF AMERICA.

WORLD'S LARGEST MANUFACTURER OF GLASS-BONDED MICA AND CERAMOPLASTIC PRODUCTS

Shown at Bell Laboratories, Murray Hill, N. J., are, left to right, F. J. Herr, S. T. Brewer, L. R. Snoke, E. E. Zajac and F. W. Kinsman.

They're wiring the seas for sound

These five Bell Labs scientists and engineers may never "go down to the sea in ships." Yet, they're part of one of the most exciting sea adventures of modern times. Along with many other specialists, they are developing the deep-sea telephone cable systems of the future.

Here's how they join many phases of communications science and engineering—to bring people who are oceans apart within speaking distance.

F. J. Herr, M.S., Stevens Institute, is concerned with systems design and analysis. He studies the feasibility of new approaches and carries out analysis programs to select optimum parameters for a proposed system design.

S. T. Brewer, M.S. in E.E., Purdue, communications and electronics engineer, explores new designs for sea-bottom amplifiers needed to step up power of hundreds of simultaneous telephone conversations.

L. R. Snoke, B.S. in Forestry, Penn State, is the team biologist. He investigates the resistance of materials to chemical and microbiological attack in sea water. Materials are evaluated both in the laboratory and in the ocean.

E. E. Zajac, Ph.D. in Engineering Mechanics, Stanford, is a mathematician. He studies the kinematics of cable laying and recovery. Cable's dynamic characteristics, ship's motion, the mountains and valleys in the ocean bottom—all must be taken into account.

F. W. Kinsman, Ph.D. in Engineering, Cornell, solves the shipboard problems of storage, handling and "overboarding" of cable. New machinery for laying cable is being developed.

Deep-sea cables once were limited to transmitting telegraph signals. Bell Labs research gave the long underseas cable a voice. New research and development at the Labs will make this voice even more useful.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

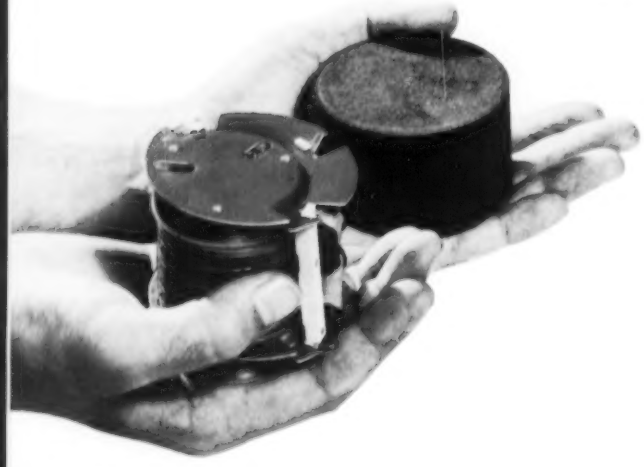
- High Voltage Station Class Lightning Arresters No Taller Than a Switch Insulator Stack
- 230-kv And Higher Arresters That Can Be Tank-Mounted Due To Their Small Size
- By Far The Highest Durability And Protective Factors Ever Available

An Entirely New Conception of Lightning Arrester is Described on the Following Pages

New Applications result from radically

THOREX ®

Dynagap Exploits Small Size Into Big Economies and Advantages

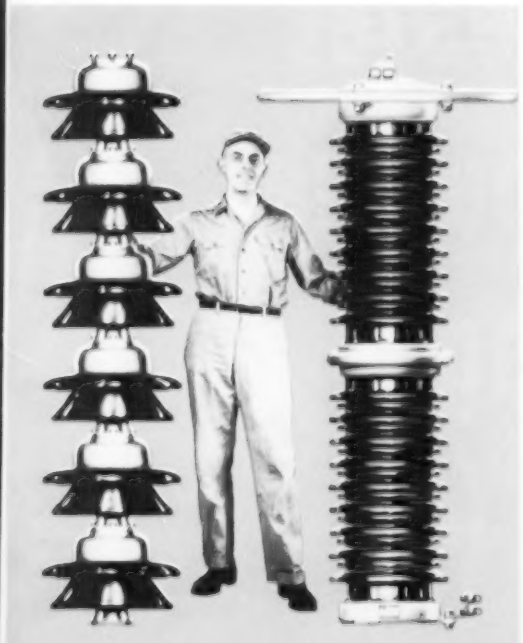


As used in new Thorex station class lightning arresters, here is a Dynagap and valve block—scarcely a double handful!

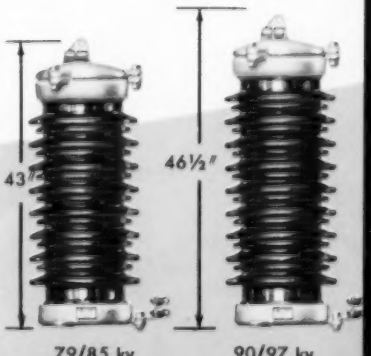
Never before has so much efficiency—and so much technical improvement—been put into such compact arrester parts.

In station class arresters, this permits three columns of active elements to be stacked side-by-side in a housing only 16¾ inches in diameter. This has the effect of shortening the arrester to only one-third the conventional height. It produces a sturdy, self-supporting, totally un-cluttered unit, so small you can hardly believe it is a high-voltage lightning arrester from your previous experience.

New Thorex Dynagap arresters for service from 115 to 345 kv are almost exactly the height of an equivalent-rated switch insulator stack and slightly smaller in diameter. They also practically level-off with the height of a bushing above the flange line.



Striking height saving of the new Dynagap arrester is illustrated here, at the 230-kv level. The Dynagap type MPR 195 has a height of only 85¾ inches—scarcely half that of the previous "smallest" design—only one-third that of conventional end-to-end assembly practice. This great physical advantage in the new Thorex arrester will stimulate some entirely new thinking on the part of station designers, as to possible arrester location in more advantageous places. The arrester can be rigidly base or cap mounted or flexibly suspended. Height of the type MPR 195 is compared with that of a standard NEMA switch insulator stack for the same voltage.



Ohio Brass ®

...Big Savings...
reduced arrester height

Ever hear of tank-mounting an arrester for 345-kv service right next to the apparatus bushings? Now, it is feasible. Protective value of such an arrangement would be greatly enhanced. At lower transmission voltages, 230 kv for example, you would be dealing with an arrester only 86 inches high; at 138 kv, only 57 inches. These are within present routine tank-mounting dimensions—*but not voltages!* Radically reduced size of station class Dynagap arresters opens up tremendous opportunity for direct application to major apparatus—for a resulting superior grade of protection—for installation economies too obvious to belabor.

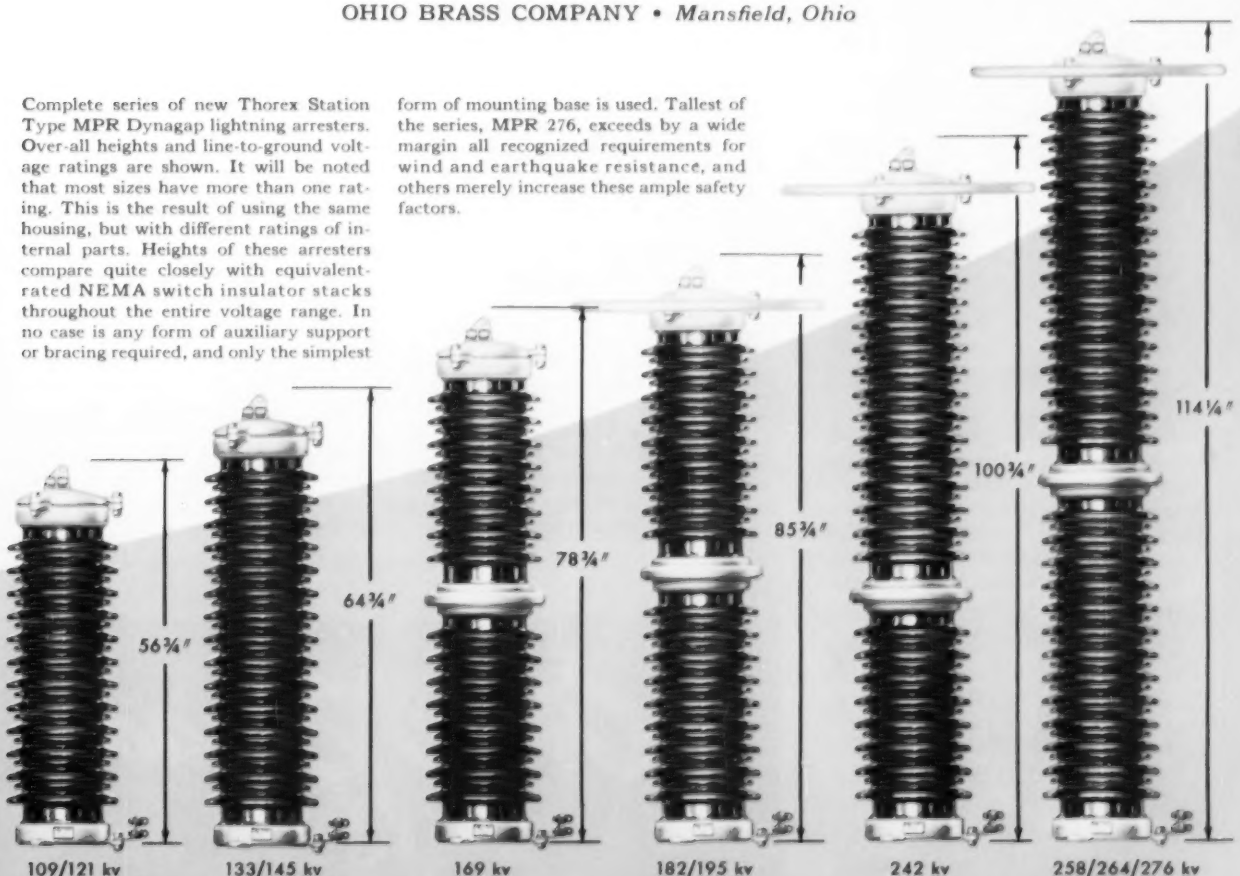
Practically speaking, you can put a new Thorex Dynagap station class arrester almost anywhere an insulator stack can be mounted. Right on steelwork if necessary. In any event, all the foundation required is a small concrete base or simple pedestal. No auxiliary bracing or support of any kind is used. This class of economy will generally pay for the arrester.

A thorough discussion of all new station class Dynagap features would more than fill this book. Small size is only one. Unheard-of surge durability and complete freedom internally from contamination effects are just two more. The whole story adds up to a new lightning arrester—not the ordinary periodic design revision.

For an entirely fresh conception of station protection, start now using the revolutionary new Thorex Dynagap.

OHIO BRASS COMPANY • *Mansfield, Ohio*

Complete series of new Thorex Station Type MPR Dynagap lightning arresters. Over-all heights and line-to-ground voltage ratings are shown. It will be noted that most sizes have more than one rating. This is the result of using the same housing, but with different ratings of internal parts. Heights of these arresters compare quite closely with equivalent-rated NEMA switch insulator stacks throughout the entire voltage range. In no case is any form of auxiliary support or bracing required, and only the simplest form of mounting base is used. Tallest of the series, MPR 276, exceeds by a wide margin all recognized requirements for wind and earthquake resistance, and others merely increase these ample safety factors.



Same Essential Parts

. . . Used in Both Station and Distribution Classes of Thorex Dynagap Arresters

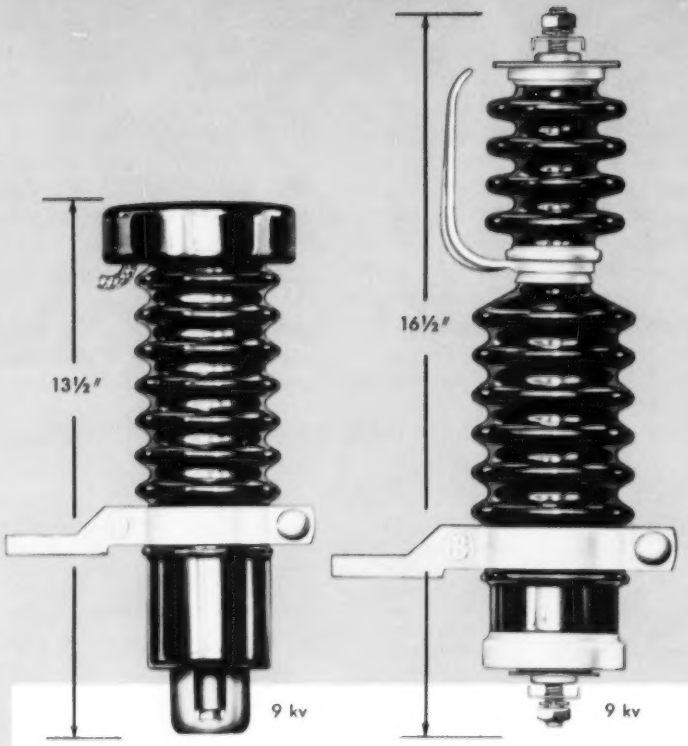
Compact Elements Permit Overall Height Reduction To As Much As Half That of Comparable Equipment

● Small size of the Thorex Dynagap permits use of a revolutionary principle in distribution arrester design. Exactly the same essential elements used in the highest voltage station types are now incorporated into new Thorex distribution arresters. In the smallest and lightest pole-top arrester yet made are vital parts having the ruggedness and high refinement to meet the exacting requirements of major station protection.

Resulting from this unique interchangeability of critical parts between the two extremes of service, the new Thorex Dynagap distribution lightning arrester establishes a whole new order of performance and protection. In many respects it is not comparable to the ordinary conception of arresters in the distribution class.

Newest of the Thorex line, this arrester merits your careful investigation and immediate installation. Its superior protective qualities and incomparable durability are yours at no price premium.

OHIO BRASS COMPANY
Mansfield, Ohio



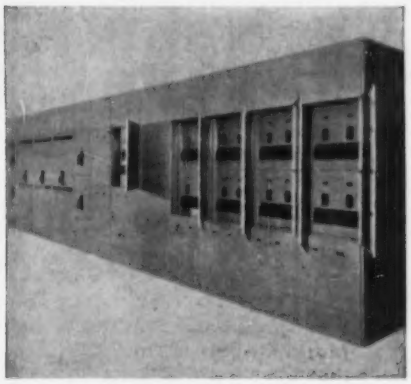
Thorex Dynagap distribution lightning arresters are made in two types, both with graduated line-to-ground ratings of 1 to 18 kv. One type is equipped with a series air gap. The other contains a similar gap within the arrester housing. It also uses the force of a small explosive rivet to free the ground lead in the event of accidental damage. While smaller and lighter than similar devices, these arresters utilize the essential elements of station class equipment to provide a new order of protection and durability. Similar models are available as regular components of distribution transformers.

Ohio Brass

4777-H

MOLDED CASE CIRCUIT BREAKERS

I-T-E plug-in mounted "Cordon" Circuit Breakers represent the maximum in flexibility, economy and safety.

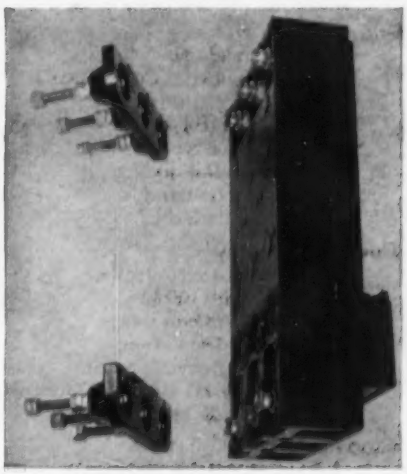


Typical switchboard installation of "Cordon" Circuit Breakers and large air circuit breakers.

I-T-E Plug-In Mounted "Cordon" Circuit Breakers Have Saved Countless Man-Hours

Plug-in mounting in switchboards provides features and advantages you get only in this modern, streamlined construction. Consider the ease of installation, the time saved in assembling switchboards. Consider the flexibility in meeting changing circuit conditions, the advantage of being able to change breakers without disturbing terminal connections. Consider, too, the added safety of concealed terminals with no live parts exposed. When you do, you'll specify switchboards with this time-proved method of installing molded case circuit breakers.

I-T-E plug-in molded case circuit breakers are available in ratings from 15 to 600 amp, up to 600 volts a-c, 250 volts d-c. Contact your I-T-E representative or leading independent switchboard manufacturers for details. Or write I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Philadelphia 30, Pa.



Used for many years in marine switchgear and approved by Underwriters' Laboratories Inc., I-T-E plug-in mounted circuit breakers require only two compact mounting blocks for switchboard installation.

I-T-E CIRCUIT BREAKER COMPANY

Small Air Circuit Breaker Division

In Canada, Eastern Power Devices Ltd.

4777-H

Improved
ELECTRICAL and MECHANICAL PROPERTIES
— make the difference!

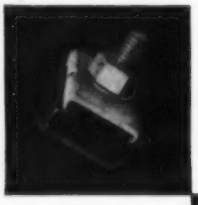
morganite

means...

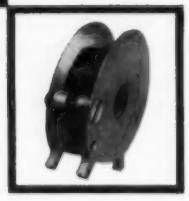
BETTER PERFORMANCE
LOWER MAINTENANCE

Motor and Generator Brushes
Morganite brushes enjoy a reputation world-wide for trouble-free service. Available for fractional horsepower, aircraft, automotive, traction and industrial applications.

Carbon Brush Holders
Assure high efficiency brush operation by maintaining positive contact between the brush and the commutator or ring. Standard types include cantilever radial, radial, trailing, reaction and AC slip ring holders.



Electrical Contacts
Including drum controllers, contactors and starters. Incorporate metals in a refractory carbon base for improved electrical conductivity and mechanical strength. Contacts are self-lubricating, non-welding.



Carbon Current Collectors
Reduce operating costs on travelling cranes. Cost less, wear longer and reduce conductor wear to a minimum. Will not blister or rough conductor, afford trouble-free service over extremely long periods.

Complete Catalogs Available — call or write today. Recommendations on specific applications supplied promptly on request.

Morganite
INCORPORATED . . . FOR OVER HALF A CENTURY
TRADE MARK 3308 48th Avenue, Long Island City 1, New York

Manufacturers of Fine Carbon Graphite Products including Carbon Specialties, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts
Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

(Continued from page 42A)

New Products

Extra-Brilliant Pilot Light. An oil-tight pilot light with a more brilliant glass cap has been put on the market. Available in clear glass or one of five bright colors, the new light offers extra resistance to chemicals and abrasion in addition to its increased visibility. For unprotected areas where breakage is a possibility, interchangeable caps of plastic can be had in the same variety of colors. The new light is part of a complete line of oil-tight pilot devices. For further information, write the Square D. Company, 4041 N. Richards St., Milwaukee 12, Wis.

Airborne Radar Indicator Recorder. A radar indicator recorder for airborne fire control systems has been announced by Beattie-Coleman Inc., formerly Photographic Products Inc., manufacturers of automatic recording cameras and precision timing instruments. This camera records range and code lights as well as radar reading. Two synchronized counters are provided, one recording optically, and the other visible to the operator. For more complete information concerning the Beattie Radar Indicator Recorder, write direct to the manufacturer, Beattie-Coleman Inc., 1000 No. Olive St., Anaheim, Calif.

Finger Pull Cord Plug. An electrical attachment cap with flexible finger pull handle can now be supplied on line cords for all types of lamps and appliances. The plug is made of plastic and can be molded on a variety of wire types and sizes in any color. Manufacturer's trademark may appear on the plug. The design is such that the wire comes out the side of the plug, so that it is easier to pull the plug

out of the receptacle by the handle rather than by the wire, an unsafe and destructive practice. An added feature is the ability to store excess length of wire off the floor by pushing several loops of the wire into the handle opening. Because the handle is flexible, it will not mar or break when furniture is moved against it. The product is furnished on line cords to manufacturers by Miller Electric Company, 120 Main St., Pawtucket, R. I.

(Continued on page 54A)

D-C VOLTMETERS
D-C AMMETERS
D-C MILLIAMMETERS
A-C and D-C VOLTMETERS
A-C and D-C AMMETERS
A-C and D-C MILLIAMMETERS
SINGLE and POLYPHASE WATTMETERS
POWER FACTOR METERS
PHASE ANGLE METERS
MICROFARAD METERS
FREQUENCY METERS

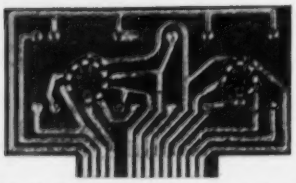
Certified
TRANSFER STANDARDS

Universal favorites for precision test requirements, the Weston Model 310 series represents the most complete line of *matched* portable precision test instruments available. All are true electrodynamometer type (except the frequency meter). The voltmeters, ammeters and milliammeters are rated within ¼ of 1% accuracy, full scale. Certificate with each instrument gives its individual electrical characteristics. For complete data on these instruments, including ranges, prices, etc., see your local Weston representative, or write, Weston Electrical Instrument Corporation, Newark 12, N. J.

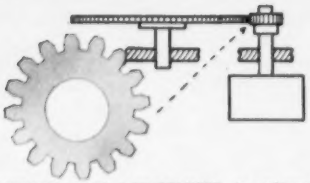
WESTON
Portable
PRECISION INSTRUMENTS

glass-base laminates?

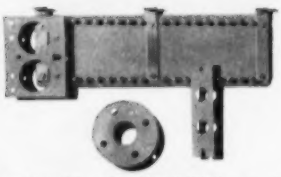
C-D-F DILECTO®
is the answer!



SPEED AUTOMATIC PRODUCTION of printed circuits with warp-resistant C-D-F metal-clad Teflon* and epoxy laminates. Other advantages: high bond strength of copper to laminate, superior blister-resistance in solder immersion.



HIGH-VOLTAGE (1800v.) RF ISOLATION is achieved by miniature C-D-F Dilecto gears in an aircraft receiver-transmitter switch. They also had to exhibit dimensional stability through a wide temperature range, resistance to fungus growth and thermal shock.



PRECISE MACHINING AND FABRICATION are standard benefits of Dilecto laminated plastics. These silicone glass-base parts (coil mountings, aircraft terminal board) were sawed, drilled, punched, and milled in production quantities by C-D-F and customer.

Teflon*, silicone, epoxy, melamine, and phenolic glass-fabric laminates. Polyester glass-mat laminates.

You can improve design, speed production, and save money by specifying one of the many C-D-F Dilecto grades. Whatever your application for these laminates — with fine- or medium-weave glass-cloth base — you'll find a better answer to your problem at C-D-F. (Melamine can also be made with glass-mat base.) And C-D-F offers modern machining and fabrication facilities to deliver production quantities of finished Dilecto parts to your specifications.

See our catalog in Sweet's Product Design File, where the phone number of your nearby C-D-F sales engineer is listed. For free trial samples of glass-base Dilecto, or of any other C-D-F plastics, mica, or fibre product, send us your print or your problem! Write for your free copy of C-D-F Technical Bulletin 64.

*DUPONT TRADEMARK FOR TETRAFLUOROETHYLENE RESIN

PROPERTIES OF SOME TYPICAL C-D-F DILECTO GLASS-BASE GRADES

Grade	Equivalent NEMA or ASTM grade	Flexural Strength Lengthwise (PSI)	Dissipation Factor at 10^{6} Cond. A	Dielectric Strength Parallel Step x step	Insulation Resistance Cond. C96/35/90	Arc Resistance (seconds)	Maximum Operating Temp. (°C.)
GB-112T (Teflon*)	None	14,000	0.0015	65	100,000	180+	250
GB-12S (Silicone)	G-7	28,000	0.002	60	100,000	180+	200
GB-28E (Epoxy)	G-10	70,000	0.019	65	75,000	130	150
GB-28EFR (Flame-Retardant Epoxy)	G-10	68,000	0.010	65	100,000	180	150
GB-28M (Melamine)	G-5	50,000	0.014	50	100	185	135
GB-261D (Phenolic)	G-1 and G-2	22,000	0.020	55	10,000	5	150
GM-PE (Polyester)	GPO-1	35,000	0.020	70	200	130	150

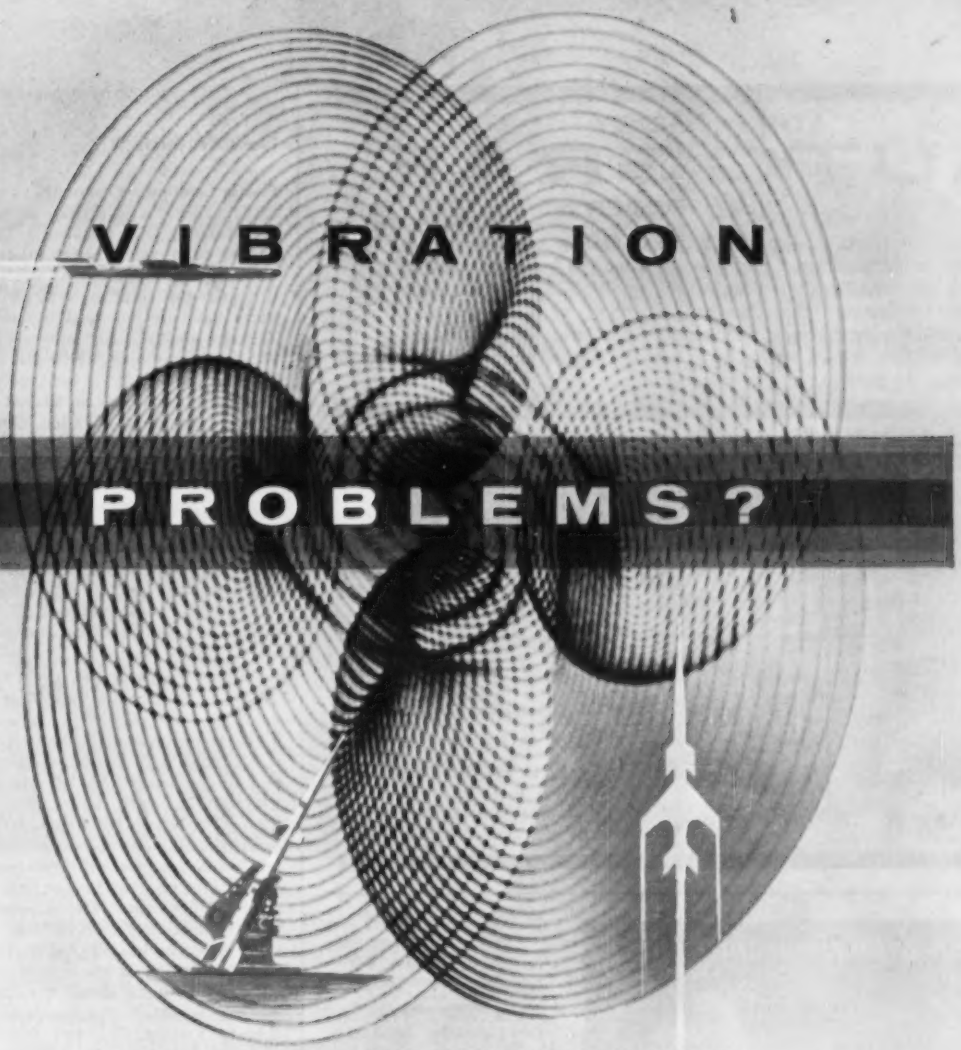
These are typical grades for typical applications. To meet special requirements, C-D-F makes many other Dilecto grades, one of which may serve your purpose better than any of these listed here. Consult the C-D-F Technical Department for expert assistance with your design problem involving laminated plastics products.

CDF

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Budd COMPANY • NEWARK 86, DELAWARE

VIBRATION PROBLEMS?

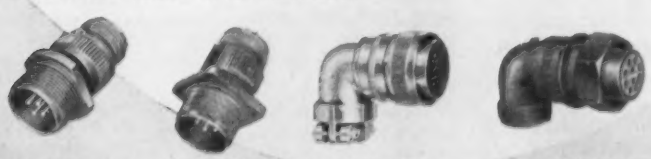


CALL OUT CANNON PLUGS

Improvements are constantly being made in Cannon connectors to give you maximum reliability in circuitry under constantly increasing highly critical vibration conditions. New lines... improvements on the AN-E design... include the EX, the CT, the EA, and the EB Series.

You'll find Cannon vibration and moisture-proof resilient-insert lines extensive and complete, in hundreds of carefully designed layouts. Interfacial sealing. Improved grommets and grommet followers. Styles with extra strong coupling nuts. Telescoping rubber bushings. Strong clamps. Means for safety wiring. Grounding lugs. Every facility to give solutions to vibration, moisture condensation, flashover, and corona problems.

Vibration-proof Series include AN-E, CA-AF, CA-F, CA-FN, EA, EB, EX, and CT. Write TODAY for full information.



CA 3101 AF
Pin Assembly

CA 3100 F
Wall Mounting Receptacle

AN 3108 E
63 Inserts Available

CA 3108 AF
90° with Hex Nut

For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

CANNON PLUGS
WHERE RELIABILITY IS THE 5TH DIMENSION

Write for 44-page, 2-color Plug Guide, Bulletin CPG-3

Please Refer to Dept 117

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, Calif. Factories in Los Angeles, Salem, Mass., Toronto, Melbourne, London. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities.

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AUTOGRAF
X-Y RECORDER
trade mark

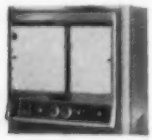
A pioneer in its field, the Moseley AUTOGRAF X-Y Recorder is being adapted to an ever increasing number of graphic recording and data translating problems. Carefully manufactured to precision standards, the AUTOGRAF is available in five models to fit your particular requirement.

In addition to curve drawing, a full complement of accessories facilitate use of the AUTOGRAF in point plotting, curve following, card and tape reading, and gain-frequency plotting.

Model 1 portable type

Model 2A flat-bed

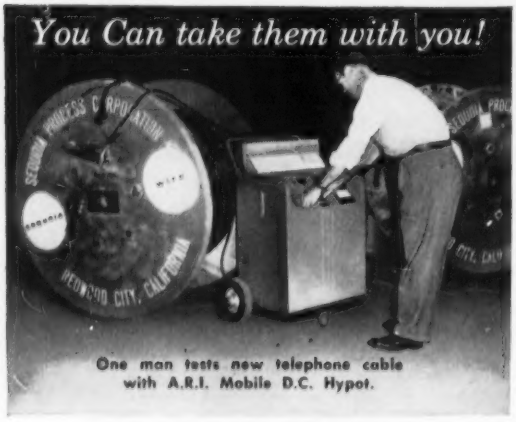
Model 3 desk type


Model 4 rack type

Model 5 rack type

Write for complete information:

F. L. MOSELEY CO.
409 NO. FAIR OAKS AVENUE
PASADENA, CALIFORNIA



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D. C. HIGH POTENTIAL TESTERS
(Ranges up to 75,000 V.D.C.)

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ACCURATE
EASY TO
OPERATE

For testing
Wire • Cable • Potheads
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Only one man is required to test with Mobile D.C. Hypots . . . and operation for fast, simple, accurate tests is quickly learned, virtually foolproof.

Mobile Hypots roll like a golf cart—have traveled thousands of miles in station wagons and utility trucks without crating or padding.

Whether you are testing in plant, warehouse or in the field, Mobile D.C. Hypots save time and manpower—give positive, accurate tests of dielectric strength.

Write for new Bulletin 5-1.1, for data on all D.C. "Hypots". Sent free on request.

ASSOCIATED RESEARCH, Incorporated
"Electrical Testing Instruments Since 1936"
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Field Representatives in Principal Cities
Export Dept., 549 W. Washington Blvd., Chicago 6, Illinois

(Continued from page 50A)

New Products

Plastic Laminate. Economies ranging from 35% to 75%, matchless ease of fabrication, permanence, and sculptured beauty are offered to users of bright plated metals, wood veneers, grained or textured plastics, and acoustical materials by Pearsonite, a basically new and superior plastic. The new material, announced by Metallic Plastics Corporation, 27-10 44th Dr., Long Island City 1, N. Y., behaves amazingly like light-gauge sheet metal and faithfully retains the most detailed three-dimensional forms. Pearsonite has an almost limitless range of application in the appliance and electronic fields. Typical uses include trim, nameplates, emblems, and grills for refrigerators, air conditioners, radios, television sets, vending machines, and juke boxes. Pearsonite will not burn, and resists abrasion from continued hard use. Being almost completely chemically inert, it is truly maintenance-free.

Intercom. Special feedback circuits, giving very low distortion and high speaker damping, resulting in a smooth, clear, natural sound are the outstanding features of the new intercommunication system manufactured by Fisher Berkeley Corporation, 5633 Grove St., Oakland, Calif. The complete intercom system is available in either 6- or 12-station masters with remotes, with intermixing of master and remotes for innumerable possible arrangements. The masters may be set for conference calls, dictate, or talk—listen for complete flexibility. Contemporary styling allows the system to fit into any office or home decor. For more information, an illustrated brochure is available by writing to Fisher Berkeley Corporation, 5633 Grove St., Oakland 9, Calif.

Three Speed Hysteresis Motor. A 3-speed hysteresis motor which provides tape speeds of 3¾ inches, 7½ inches, and 15 inches per second with a direct drive has been introduced. Precision ground capstans are held to close concentric and diametral tolerances and designed as an integral part of the rotor shaft to insure accurate velocities with minimum of flutter. Quiet in operation, these 3-speed hysteresis motors are ideal as a precise drive for high fidelity recording and reproducing equipment such as, tape recorders, computer storage drums, turntables, etc. For further information, write to: Technical Electronics Corp., 4060 Ince Blvd., Culver City, Calif.

Relay. Available from Line Electric Company, 271 S. 6th St., Newark 3, N.J., is the *SM* series relay, in a plug-in, transparent, dust-proof enclosure. Utilizing standard octal and 11 pin bases, this relay comes in contact arrangements up to 3 P.D.T. Contacts are rated at up to 10 amperes at 115 volt a-c, noninductive. Coils in all standard a-c and d-c voltages are also available for plate circuit applications.

(Continued on page 58A)

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, Calif. Factories in Los Angeles, Salem, Mass., Toronto, Melbourne, London. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities.

ALL MACHINED TO EXACT CUSTOMER SPECIFICATIONS FROM Spaulding PRODUCTS

Spaulding Products are adaptable to intricate machining operations. They are readily sheared, sawed, turned, punched, drilled, threaded, swaged and formed.

Spaulding's fabricating departments are especially equipped and staffed to perform these operations on these materials. Even the most difficult shapes are turned out quickly, accurately and economically.

When you need a material with the unique electrical, chemical and physical properties combined in the numerous types and grades of Spaulding materials, you can specify Spaulding with assurance that the parts delivered to you will be fabricated to your precise specifications.

THE PROPERTIES OF SPAULDING MATERIALS INCLUDE

Great mechanical strength, extremely light weight, durability, chemical inertness, excellent machinery qualities, arc resistance, deionizing ability and low loss electrical insulation.

WE MAKE AND FABRICATE

VULCANIZED FIBRE: In sheets, rods, tubes and fabricated parts.

ARMITE: Thin Insulation (Fish Paper) in sheets, rolls, coils and fabricated parts.

SPAULDITE: (Laminated Thermosetting Plastic) in sheets, rods, tubes and fabricated parts.

SPAULDO: Motor Insulation in sheets, rolls, coils, slot cells and other fabricated parts.

SPAULDING FIBRE BOARD: In sheets and fabricated parts.

SPAULDING T BOARD: A superior Transformer Board in sheets and fabricated parts.

MATERIALS HANDLING PRODUCTS: Factory Trucks, Boxes, Barrels, Trays, etc.

SPAULDING FABRICATING FACILITIES: Spaulding's fabricating facilities for these products are unsurpassed the world over. You can save time and money by letting us do your fabrication. We'll be glad to quote on specific jobs without obligation.

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Typical GLASaloy Shapes

General Radio Company found GLASaloy (EG-9) the most suitable material for Potentiometer Shafts. Superior Physical Strength . . Close Tolerance . . High Dielectric Strength . . Plus Heat and Chemical Resistance were the influential factors in the selection of "GLASaloy" Shafts.

Rods . . Tubes and Irregular Shapes and Sizes of GLASaloy can be engineered to meet your various specifications. For further information clip out and fill in coupon below. GLASaloy Glass Reinforced Plastics Corp., 405 W. Sophia Street, Maumee, Ohio.

GLASS REINFORCED PLASTICS CORP.

405 West Sophia Street — Maumee, Ohio

Gentlemen; I would like more information on GLASaloy.

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WHAT DO YOU USE TO MEASURE LEADERSHIP?

In this highly technical age "close tolerances" are required standards . . . and, product wizardy is being worked today by many nationally known companies through the use of . . .

SPARTA'S

PROVEN AND PATENTED PROCESS
(Pat. No. 2,781,552)
of Custom Molding in Thin Sections and Shapes, parts of

TEFLON*

whose properties are unmatched by those of any other single material . . .

. . . offering product improvement opportunities to designers of electrical equipment never before possible.

WHEN YOU THINK OF TEFLON THINK OF SPARTA

- Trained staff of Fluorocarbon Engineers
- COMPLETE stock of all standard Teflon products
- Precision engineered parts for rigid quality control.

WRITE for complete data, prices, properties and applications without cost or obligation.
DEPT. EEng.

THE FIRST COST CAN BE THE LEAST . . . IF IT IS THE LAST COST!

*DuPont's tetrafluoroethylene resin.

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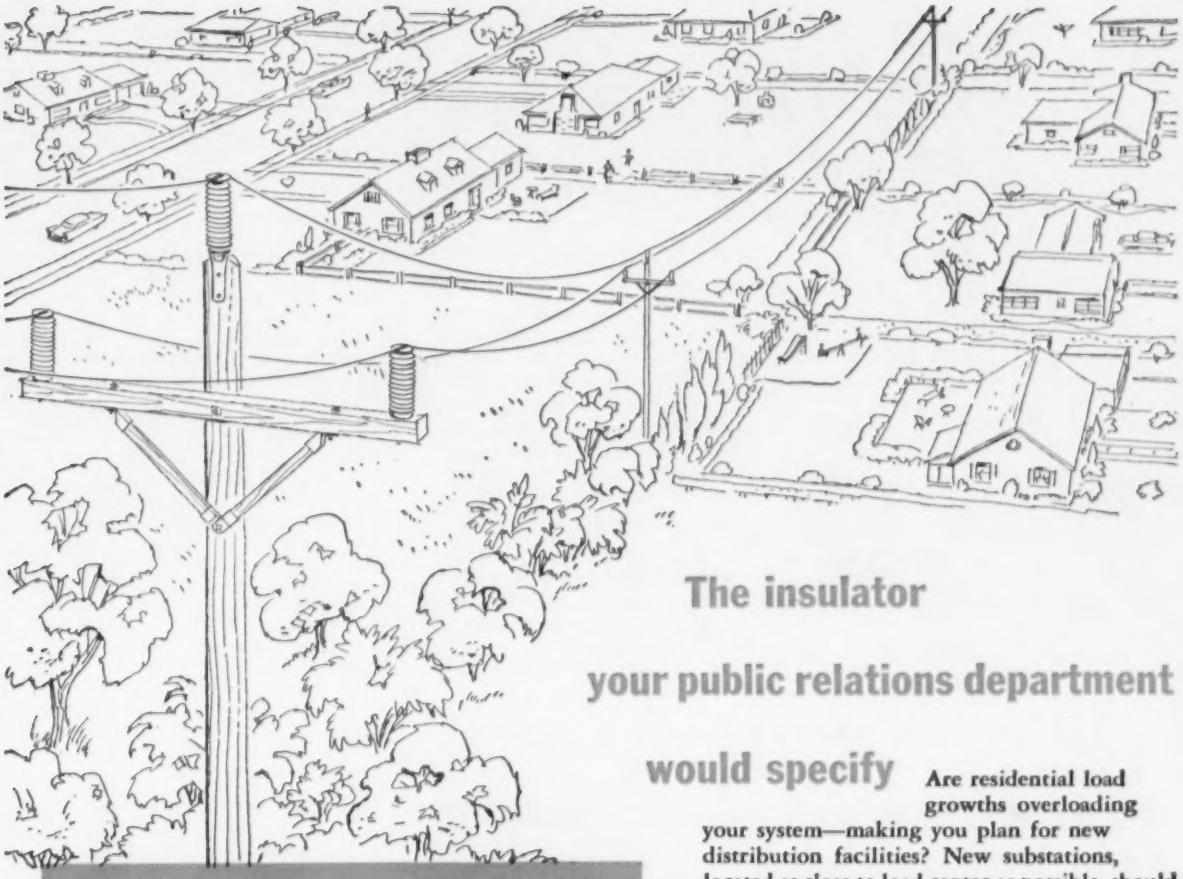


The insulator your public relations department would specify

Are residential load growths overloading your system—making you plan for new distribution facilities? New substations, located as close to load center as possible, should be your best solution—if sites are available . . . and *if* a subtransmission line through a residential area doesn't encounter customer objection. If you build such a line on large imposing structures, it probably will!

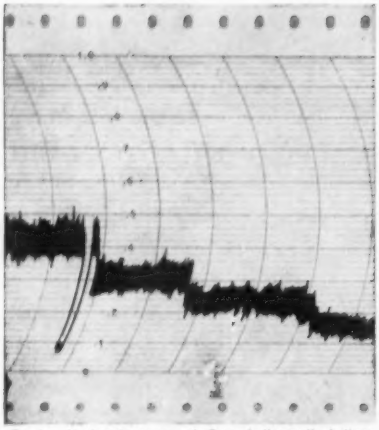
There's a wonderful way to do it, however, and one which will retain customer goodwill! A line up to 69 Kv, and even higher voltages, can go on "small" unobtrusive wood-pole structures, with single cross-arms—and compact, sturdy good-looking Lapp Line Posts. In addition to sparing customer feelings, you'll be saving money, too, in initial cost, and maintenance; service records from coast-to-coast show that such lines for subtransmission voltages are more reliable and trouble-free than any others. And particularly important for lines in residential areas is the fact that Lapp Line Posts are inherently free of RIV and TV interference at rated voltages.

Once you've installed such a line, your future problems diminish. A trim, good-looking, high performance line on Lapp Line Posts serves as a beautiful example of a complaint-free installation. It will be easier to get right-of-way for *future* transmission lines.

Lapp Line Posts, either with tie-wire head or clamp-top, are available in voltage ratings through 88 Kv.

Lapp Insulator Co., Inc., Le Roy, N. Y.

RECORDERS WORK... WHILE YOU ARE BUSY ELSEWHERE



Courtesy Nuclear Measurements Corp., Indianapolis, Indiana

This record was made by a DC Milliammeter in a monitoring unit, measuring fall-out over Indianapolis after the explosion of an experimental bomb.

The recorder was on the job continuously for 1½ days before fall-out began to increase as shown here. Meanwhile the technicians and engineers were busy at other tasks.

Make recording instruments help you multiply your effectiveness. Ask for Catalog 657.

Product Representatives in Most Principal Cities

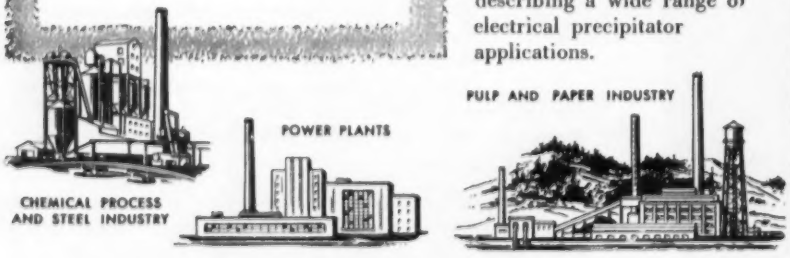
The ESTERLINE-ANGUS Company, Inc.

Pioneers in the Manufacture of Graphic Instruments

Dept. B6, P. O. Box 596, INDIANAPOLIS 6, INDIANA

Industry looks to **RESEARCH -COTTRELL** *for high dust collection efficiencies*

To maintain visually clean stacks at all times, industry is turning to the long experience of Research-Cottrell in the design and manufacture of highly efficient Cottrell Electrical Precipitators. We've spent 40 years in solving such problems as nuisance abatement, cleaning gas for subsequent use and recovering materials of value. Write for illustrated bulletin describing a wide range of electrical precipitator applications.



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RC 197 *228 N. La Salle St., Chicago 1, Ill. • 111 Sutter St., San Francisco 4, Cal.*

(Continued from page 54A)

New Products

10-Story-High Furnace. The nation's tallest heat treating furnace, higher than a 10-story building, is in operation at the Harvey Aluminum plant, Torrance, Calif. The vertical electric furnace, 110 feet high and 7 feet in diameter, was designed and constructed by the Industrial Heating Division, Westinghouse Electric Corporation, Box 2278, Pittsburgh, Pa., to heat treat extruded aluminum alloy shapes. The furnace provides controlled temperatures to multiply several times the strength of precision aluminum for aircraft, construction, and other uses.

Ultrasonic Transducer. This transducer, Model *UT-2-42*, for ultrasonic cleaning, degreasing, and processing, has been announced by Vibro-Ceramics Division, Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J. Using Glennite piezoelectric ceramics, the ultrasonic transducer is designed for modular assembly to cover large areas with nonfocusing and uniform sound field. It has a high conversion efficiency and a frequency for many types of processing. Hermetically sealed in stainless steel housing, the Model *UT-2-42* is completely immersible in organic solvents, aqueous solutions of normal detergents, mild alkalis, or acids. For more information, write James Heacock at the aforementioned address.

Permanent Marking of Electron Tubes. A truly permanent marking ink has recently been developed by Raytheon engineers and is in daily use in the production of important military miniature and subminiature types of electron tubes. This marking withstands all attempts to remove or destroy it short of actually grinding away the glass on which it appears. It easily meets the requirements of Mil. Spec. Buffing, rubbing, heat, or humidity may dim the strength of this marking but it remains readable. For further technical information write to Technical Information Service, Raytheon Manufacturing Company, 55 Chapel St., Newton 58, Mass.

Vhf Amplifier. An automatic level controlled, broadband vhf amplifier which incorporates the latest advancements in circuit design and components has been announced. Model *LRA-40* trunk line amplifier is equalized to compensate for cable slope between 53 mc and 89 mc with a flatness of ±0.25 db. It can deliver up to 0.2 volts output into a 75 ohm load and has a maximum gain of 45 db on channel 6. The automatic level control uses stable, drift-free circuits to hold the output level within 1 db for 10 db increases of input level. The input stage of the amplifier uses the newly developed 6,922 long life, low noise, dual triode to achieve an 8.5 db noise figure. A constant voltage transformer and silicon diodes provide an efficient, reliable power supply that requires only 45 watts and maintains an output stability of ±0.2 db for ±20% line voltage variations. Write Entron, Inc., P. O. Box 287, Bladensburg, Md.

(Continued on page 62A)

the NEW AMPlivar splice plus new horizontal machine

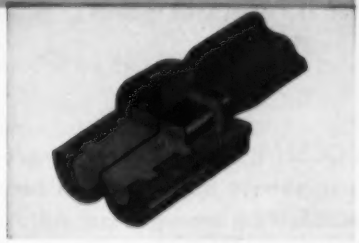
for identical, mass produced splices of enamel, poly-vinyl acetal and similarly coated wire

AMPlivar splices can be used on solid or stranded conductors, or combinations thereof.

AMPlivar splices, with multiple ring stripping action, eliminate scraping, dissolving in solvents, burning, or other methods for removing insulation. Included among its many other features are:

- NO HEAT DAMAGE TO WIRE OR INSULATION—as often occurs in alternate methods of splicing.
- SMALL SIZE—scarcely larger than the wires themselves, but design-engineered to lock wire and connector into a high tensile strength splice.
- CORROSION RESISTANT—the joint is hermetically sealed during splicing.
- LOWER INSTALLED COSTS—eliminates soldering materials and equipment . . . requires less wire . . . reduces time required to make the splice.

Further information is available on request.



This cutaway of the AMPlivar splice shows how conductor material extrudes outwardly into serrations for added strength and electrical contact. The splice is as corrosion resistant as the wire itself.

IDEAL FOR ASSEMBLY LINE PRODUCTION . . . the AMP Horizontal Automachine uses AMPlivar splice connectors in strip form, for automatic splicing as fast as the operator can insert the wires.

AMP INCORPORATED AMP

General Offices: 4113 Eisenhower Blvd., Harrisburg, Pa.

Wholly Owned Subsidiaries: Aircraft-Marine Products of Canada Ltd., Toronto, Canada • Aircraft-Marine Products (G.B.) Ltd., London, England • Societe AMP de France, Le Pre St. Gervais, Seine, France • AMP—Holland N.V., 's-Hertogenbosch, Holland
Japanese Distributor: Oriental Terminal Products Co., Ltd., Tokyo, Japan

NOW

connections that will last forever with

DOSSERT WELDING ALUMINUM CONNECTORS

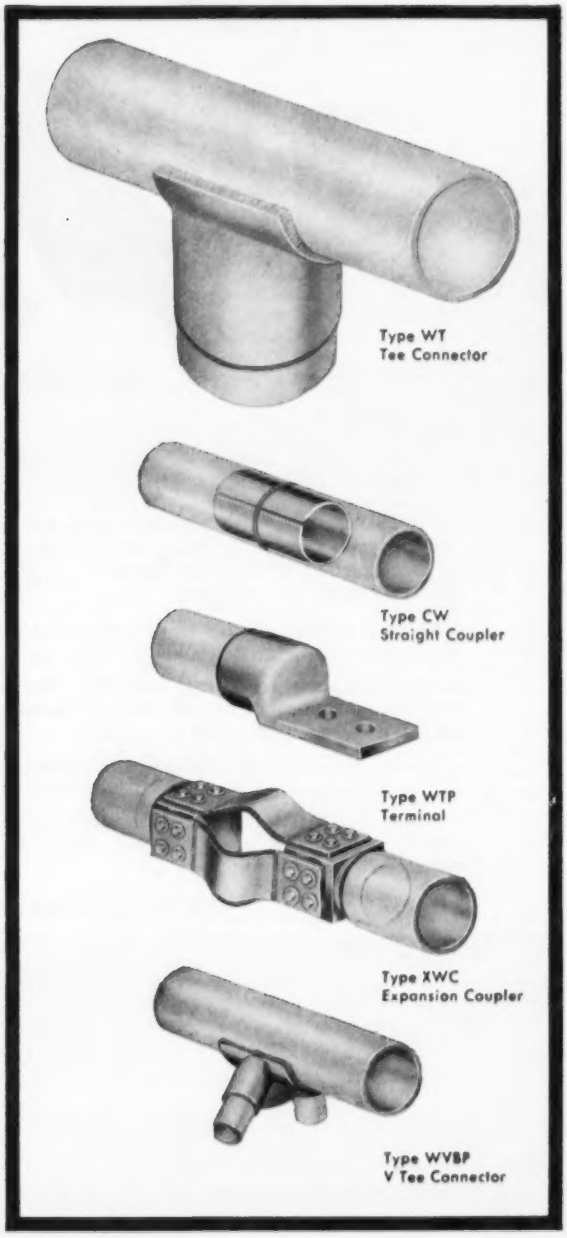
the most diversified line for substations and generating plants

DOSSERT connectors offer economy as well as long service life. They can be simply and easily installed by inert-gas arc welding, resulting in an all-aluminum weld.

These aluminum connectors feature:

- no contact resistance
- minimum maintenance
- higher corrosion resistance
- greater structural strength
- neater appearance

We also welcome inquiries on modifications or applications.



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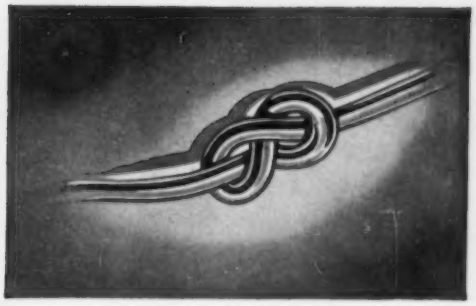
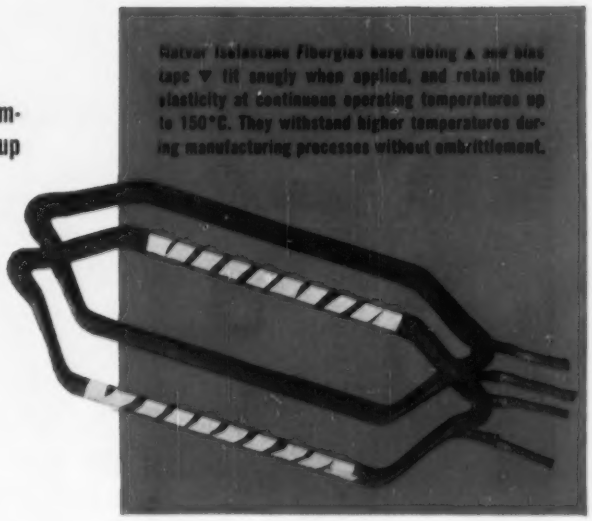


New NATVAR ISOLASTANE TUBING and TAPE*

✓ **HEAT RESISTANT** —for continuous performance at temperatures up to 150°C

✓ **RESILIENT, ELASTIC** — for sharp bends and irregular surfaces


Natvar Isolastane Fiberglas base tubing ▲ and bias tape ▼ fit snugly when applied, and retain their elasticity at continuous operating temperatures up to 150°C. They withstand higher temperatures during manufacturing processes without embrittlement.

*ISOLASTANE *is Natvar's new elastomeric isocyanate type coating for Fiberglas braid and tape. Registration pending.*

Natvar Isolastane is now making important savings possible. It makes it unnecessary to use expensive Class H materials to solve temperature problems during the manufacture of products which do not require Class H rating.

Isolastane is outstanding in its

- ELASTICITY (EXTENSIBILITY)
- RESISTANCE TO HEAT
- RESISTANCE TO CRAZING AND CRACKING
- RESISTANCE TO SOLVENTS, INCLUDING THE ASKARELS
- TOUGHNESS AND ABRASION RESISTANCE
- WET DIELECTRIC STRENGTH
- LOW TEMPERATURE FLEXIBILITY
- FUNGISTATIC QUALITIES
- ADHESION TO GLASS

Full technical data and samples are available on request.

Natvar

Natvar Products

- Varnished cambric—cloth and tape
- Varnished canvas and duck
- Varnished silk and special rayon
- Varnished—Silicone coated Fiberglas
- Varnished papers—rope and kraft
- Slot cell combinations, Aboglas®
- Isoglas® sheet, tape, tubing and sleeving
- Vinyl coated—varnished—lacquered tubing and sleeving
- Extruded vinyl tubing and tape
- Styroflex® flexible polystyrene tape
- Extruded identification markers

Ask for Catalog No. 23

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8 GOOD REASONS

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Using the improved HYSOL 6230 System

to Protect Printed Circuits

1. SURVIVES SEVERE THERMALSHOCK
2. RESISTS HIGH HUMIDITY
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4. BETTER FLEXIBILITY
5. SPRAY, BRUSH OR DIP
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7. NO SPECIAL CLEANING
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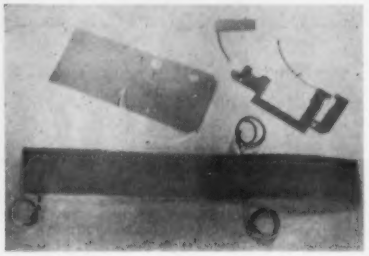
PROGRESSIVE PRODUCTS THROUGH CHEMICAL RESEARCH

In Canada
HYSOL (CANADA) LTD.
TORONTO 17

(Continued from page 58A)

New Products

Laminated Woven Electric Heaters. Thin enough to fit into cramped instrument spaces, flexible enough to be bent around sharp corners, and availability in practically any physical shape are advantages of a new group of heaters that permit wide design of flexibility in adapting electric



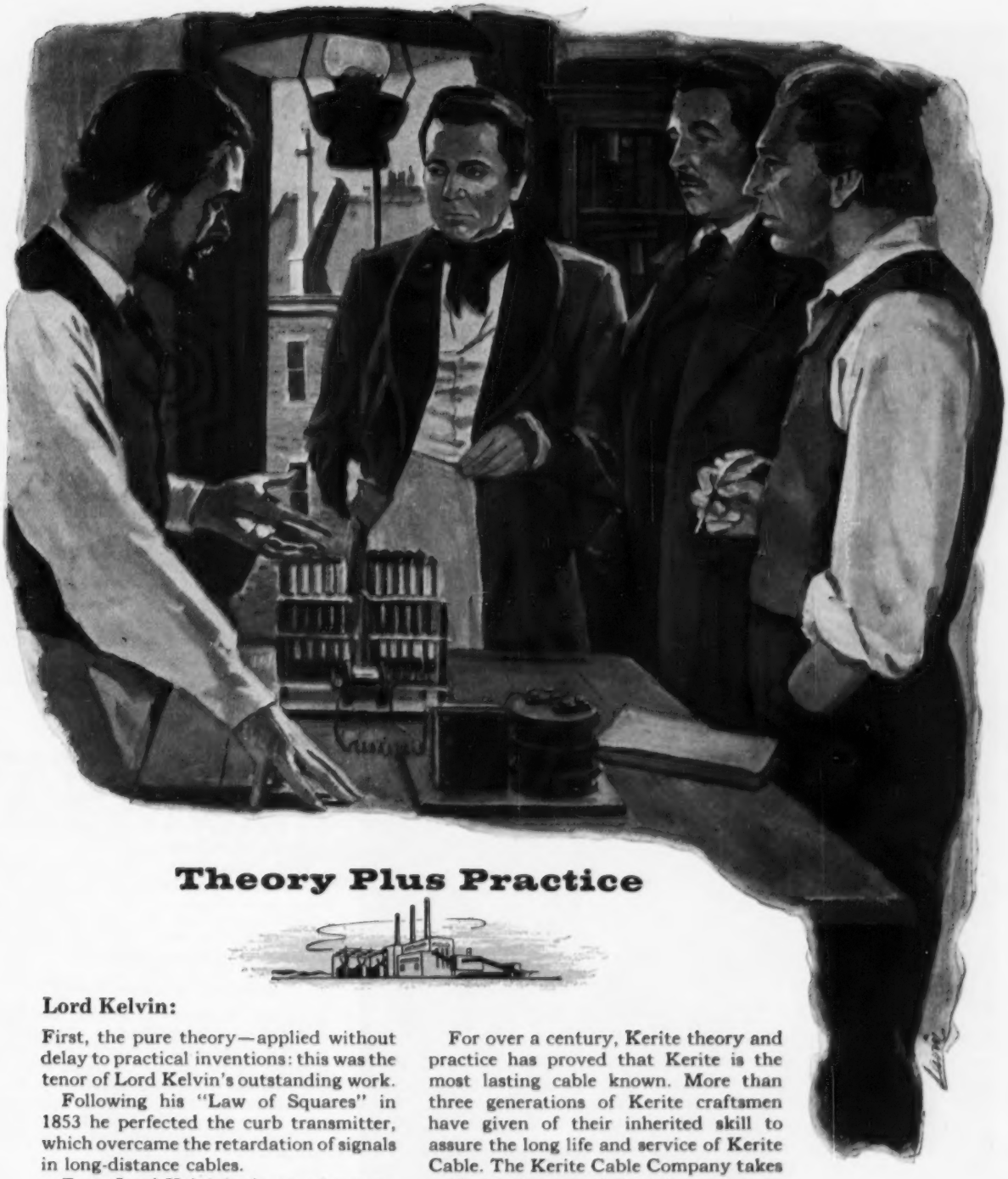
heat. Designated as Pre-Fab laminated woven electric heaters, they are custom-made by Pre-Fab Heater Division, Chromalox, Inc., 600 Ridgely St., Murfreesboro, Tenn. More information may be obtained by writing to the manufacturer.

High Power Diode. A high power, high vacuum diode, for use in charging, shunt, or rectifier applications, has been introduced by the Components Division of International Telephone and Telegraph Corporation, 100 Kingsland Rd., Clifton, N.J. Designated the *F-7030*, the tube has a maximum peak inverse voltage rating of 25 kv. Under shunt conditions, maximum peak plate current of 75 amperes and average plate current of 200 milliamperes

Handy-Boesser Photo

are obtainable. In rectifier applications the ratings are 30 amperes maximum peak plate current and 6 amperes maximum average plate current, respectively. Tube impedance at 250 plate volts is within the range of 65 to 80 ohms. The *F-7030* is characterized by an exceptionally rugged internal structure capable of long trouble-free service.

(Continued on page 70A)



Theory Plus Practice

Lord Kelvin:

First, the pure theory—applied without delay to practical inventions: this was the tenor of Lord Kelvin's outstanding work.

Following his "Law of Squares" in 1853 he perfected the curb transmitter, which overcame the retardation of signals in long-distance cables.

From Lord Kelvin's theory plus practice, more than a century ago, stem today's advances in communications.

For over a century, Kerite theory and practice has proved that Kerite is the most lasting cable known. More than three generations of Kerite craftsmen have given of their inherited skill to assure the long life and service of Kerite Cable. The Kerite Cable Company takes pride in the fact that their product is chosen by buyers of integrity to safeguard installations around the world.

The value and service life of a product can be no greater than the integrity and craftsmanship of its maker.

Founded 1854

KERITE CABLE

THE KERITE COMPANY—30 Church St., New York 7, N. Y.
Offices also at 122 S. Michigan Ave., Chicago; 582 Market St., San Francisco; 3901 San Fernando Rd., Glendale 4, Calif.; 31 St. James Ave., Boston; 4101 San Jacinto, Houston 4, Texas; 1010 Euclid Avenue, Cleveland 17, Ohio; 29 West Lancaster Avenue, Ardmore, Pa.

only circuit breakers
protect continuity
in automation

fewer power stoppages...
faster restarts...
guard production levels

circuit breaker protection is sure and accurate

YOU CAN BE SURE...IF IT'S Westinghouse

TIME CLOCKS DON'T STOP WHEN YOUR LINE IS "DOWN"

by H. D. Dorfman
Westinghouse Electric Corporation

Automation brings many new considerations to the maintenance of electrical systems for production plants. A pertinent example is the increasing importance of engineered protective devices.

A great deal more than ampere load supervision is required to protect electrical circuits serving automatic production units. Mobile assembly lines, interlocked with sub-assembly and component feeder carriers, represent a cost per minute that makes insurance against stoppage very important. That is why those of us concerned with the production of circuit protective equipment "harp" on the advantages of circuit breakers. Two of the cost-saving features are:

- Prevention of power interruption resulting from harmless, temporary current surges.
- Speed in restoration of power after an interruption.

Breakers More Accurate

Breakers avoid false stoppages in many ways. One is accurate calibration. There is a correct breaker for each particular current load and environmental condition. Exacting tests at our plant insure its being right before delivery.

Where temperature variations affect breaker ratings, but not conductor ratings, ambient-compensated breakers should be specified as additional insurance against current interruptions due to false temperature influences.

Breakers Increase Safety

In speed of restoring power, breaker advantages are obvious. A "tripped" breaker is immediately identified by the position of its handle. A quick flip of that handle restarts production in seconds. If a fault persists, the breaker reacts again to protect the circuit. It's all done with complete safety to the operator.

Fuse hunting, on the other hand, can be costly in accumulated man-machine-time. Locate the blown fuse . . . remove it . . . find the right replacement (still not as accurately calibrated as a breaker) . . . insert it . . . close switch. No matter how well organized your electrical maintenance crew, time is lost.

Unfortunately, the time clock does not stop ticking off the cost just because payload is cut off. Thus, the more complete your automation, the more important your need for real protection of its continuity with circuit breakers. J-30274

Generator brushes wearing rapidly?

Call your NATIONAL brush man...

TRADE-MARK

Here's how he helped one steel mill increase brush life 400%

FLOYD ANDERSON

Six-month brush life was the most this eastern steel mill could coax out of its 1500 kw generator. The result, reports "National" Carbon Brush Man, Floyd Anderson, was frequent down time plus some mighty expensive *extras.*

Rapid wear, film stripping, threading and grooving resulted in frequent stoning and excessive maintenance cost.

Floyd analyzed the generator's work load and recommended "National" carbon brushes, grade N-4. Brush wear was reduced immediately. N-4 brushes are averaging two years' service on this generator — a 400% improvement.

Floyd Anderson and his fellow "National" Carbon Brush Men have been solving industrial brush problems for years. Their experience and training — backed by "National" *long term brush development* — make them the logical consultants on any industrial brush application.

Call them today or write National Carbon Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

The terms "National", "N" and Shield Device, and "Union Carbide" are registered trade-marks of Union Carbide Corporation

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Air Flow	60 CFM
Fan Air Inlet Pressure	18 PSIA
Fan Pressure Rise	1.2 inches water
Heat Exchanger Pressure Drop	1.0 inches water
Liquid	Water Methanol (70% Methanol)
Liquid Flow	0.4 GPM
Heat Rejection*	300 Watts
Fan Power	30 Watts, 110 V., single phase, 400 cycle
Package envelope dimensions	7 x 6 x 3 inches
Package wet weight	2.5 lbs.

*Assumes Class A (85°C.) electronic components, liquid inlet temperature to heat exchanger, 55°C. Includes heat from fan motor.

This high performance AiResearch package cools sealed and pressurized electronic equipment. The fan circulates air through the liquid cooled heat exchanger and over electronic components in a hermetically sealed module. Air cooled units are also available. Fan and heat exchanger are designed, built and packaged by AiResearch for matched performance. Package size is tailored to your individual cooling requirements.

The Garrett Corporation, through its AiResearch Manufacturing divisions, is an industry leader in components and cooling systems for aircraft, missiles and nuclear applications. This wide experience is now being offered to the electronics industry to provide a cooling package to meet any cooling requirement. Send us details of your problem or contact the nearest Airsupply or Aero Engineering office for further information.

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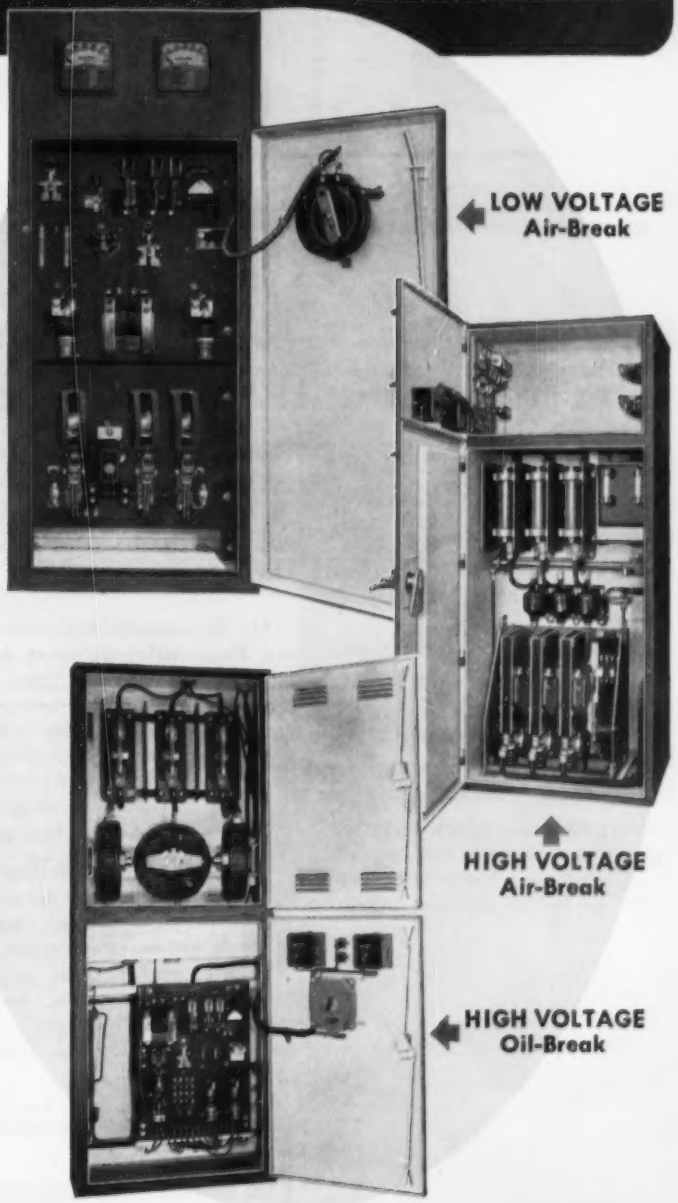
IT'S EC&M FOR A COMPLETE LINE OF SYNCHRONOUS MOTOR STARTERS!

FOR ALL LOW VOLTAGES AND FOR 2200-4800 VOLT POWER SYSTEMS!



Here's Why EC&M Pushbutton Automatic Starters Do The Job Better...

Complete protection during starting, acceleration and while running at synchronous speed.

Motor pulls into step without delay because field is applied under best conditions for synchronization.

Automatic field removal and re-synchronization allow motor to accelerate and re-synchronize after voltage dip or momentary overload.

Easily installed because all internal wiring is complete.

Full or reduced voltage starting All high voltage starters available in 3 ratings: (*1*) 50,000 KVA (certified) interrupting capacity—(*2*) with power-type, current-limiting fuses—(*3*) VALIMITOR® (volt-ampere-limitor), the bus may be of unlimited KVA.

Write for Bulletins 8200 and 8820

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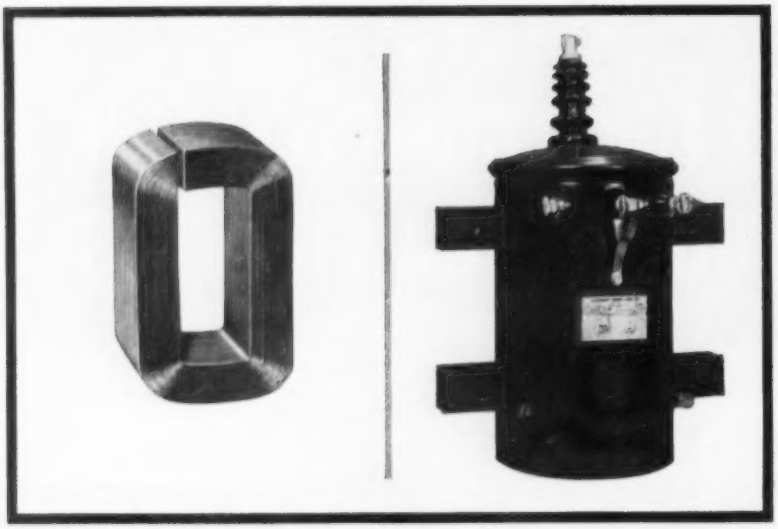


Indiana Hyflux 1-piece wound core (left) used in the new NECO Distribution Transformer (right). 1-Piece core permits faster assembly of transformers . . . reduces production costs.

Indiana Hyflux 1-piece transformer cores are more efficient . . . reduce electrical losses

. . . says Leo Rodems, President, Northern Engineering Co.

Northern Engineering Company, Baraboo, Wisconsin, manufacturer of NECO distribution transformers, have redesigned their product to use Indiana Hyflux 1-piece wound cores which consist of just *one piece with one gap* ⊐ instead of two pieces with two gaps ⊏⊐ (as in conventional C-type cores).

Mr. Leo Rodems, Northern Engineering's president, reports that the Indiana Hyflux 1-piece core is far more efficient, uses lower excitation currents, has lower electrical losses, and permits reduction of the over-all size of the transformer.

Mr. Rodems also states that Northern Engineering is using Indiana Hyflux 1-piece wound cores to rebuild distribution transformers . . . and finds it easily possible *to increase greatly the power capacity of these older transformers.*

More and more transformer manufacturers are finding that the simplified 1-piece design of Indiana cores *substantially reduces transformer assembly time, and permits important assembly cost reductions.* And inasmuch as vacuum impregnating is not necessary, the electrical losses that might result are eliminated . . . (only the sides of these 1-piece cores are varnished).

With C-cores, the two halves must be kept and used together to insure a flush fit of their ground pole faces, but with Indiana 1-piece cores, there is *no chance of mixing different pairs of halves.* And the slight "tilt" sometimes present on the ground pole faces of C-cores is not a factor.

1-Piece wound core catalog available. This 8-page catalog gives complete details covering the design and development of Indiana 1-piece wound cores. Request Catalog 14-T10 (or ask for a call by an Indiana Sales Engineer).

1-Piece cores are flexible and may be readily spread apart for winding assemblies . . . In volume production, spreading is accomplished by means of a simple, inexpensive, mechanical, spreading unit.

THE INDIANA STEEL PRODUCTS COMPANY
VALPARAISO, INDIANA

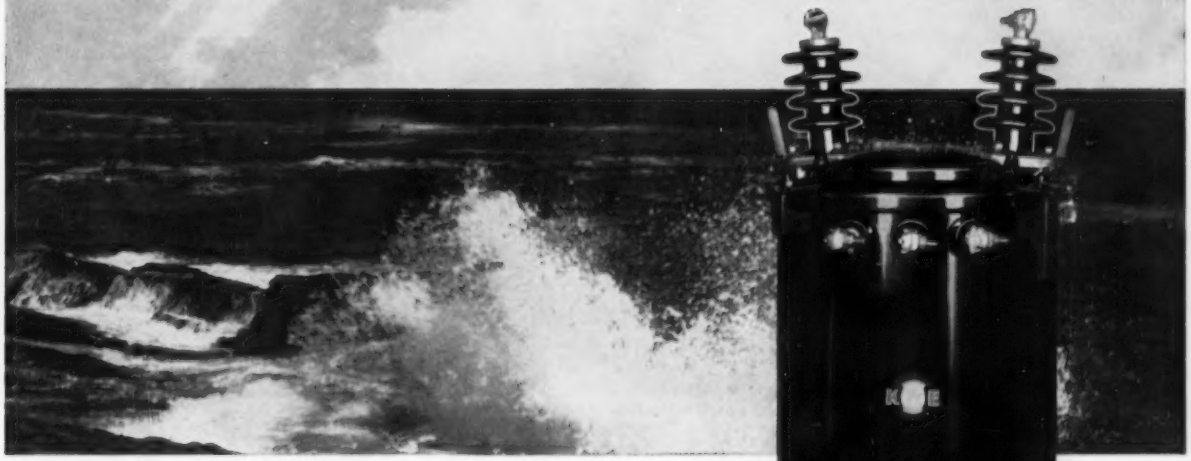
PERMANENT MAGNETS OF ALL KINDS . . .
HYFLUX 1-PIECE CORES

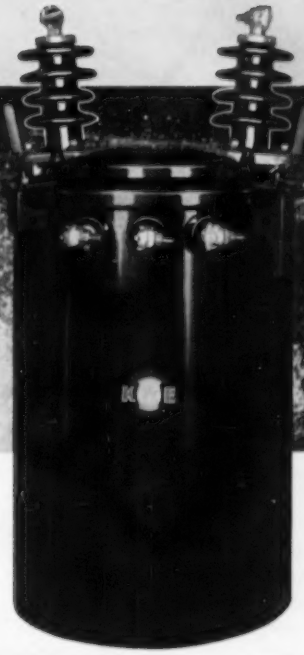
INDIANA STEEL PRODUCTS

In Canada . . . The Indiana Steel Products Company of Canada Limited, Kitchener, Ontario

17 Years of continuous service

prove Kuhlman Porcelain Enamel Transformers give positive protection against salt spray and corrosion





Utilities have used Kuhlman Porcelain Enamel Transformers since 1938. They report no deterioration in the enamel finish after 17 years of continuous service.

These units, serving in areas of heavy salt spray and industrial corrosion, have proven that Kuhlman porcelain enamel is far superior to ordinary finishes which corrosive atmospheres destroy in a short time. In every reported case, Kuhlman's exclusive finish is saving maintenance and repainting costs—shows no signs of rusting, cracking, or fading under the most severe conditions.

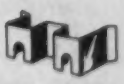
It is no wonder that Kuhlman porcelain enamel resists corrosion. Unlike paint, it is permanently fused to the tank metal at 1500° F forming a glass coating three times the thickness of ordinary paint. The resulting rock-hard surface makes an attractive, durable transformer finish—guaranteed to give you long life corrosion-free service.

For more facts about Kuhlman porcelain enamel transformers, write or ask for bulletin PB-140.

YOU GET THIS POSITIVE PROTECTION:

- **Non-Corrosive external hardware**

- **Well protected support lugs**

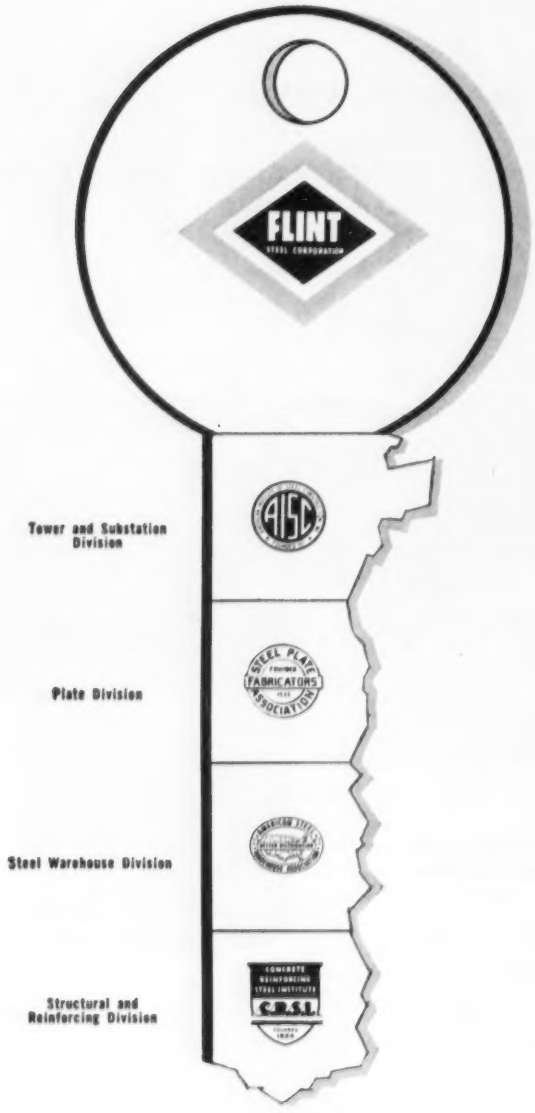


- **Protected seams, welds, and bushing openings**

- **Heavy coating on the bottom of the tank**

KUHLMAN ELECTRIC COMPANY

BAY CITY, MICHIGAN • CRYSTAL SPRINGS, MISSISSIPPI • SALINAS, CALIFORNIA



The key to successful bidding and a source for steel fabricated to your most exact specifications could be any one or all four of Flint's divisions — Structural and Reinforcing — Tower and Substation — Plate Products and Steel Warehouse.

Some clients take advantage of all FOUR DIVISIONS, others one or more.

for over 40 years

FLINT STEEL CORPORATION

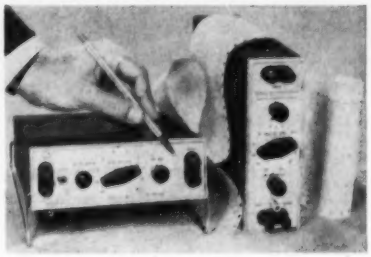
TULSA . . . MEMPHIS

(Continued from page 62A)

New Products

Meter-Relays and Meters. Six-volt illumination is now available with the black plastic 4 1/2-inch rectangular models of contact meter-relays, panel meters, and pyrometers made by Assembly Products, Inc., Chesterland 60, Ohio. Two 3-volt, 0.19-ampere aviation lamps, connected in series, are screwed into the meter cases from the front. This screw-in feature, believed to be exclusive with Assembly Products in the instrument field, results in lamp installation that is dust-tight and almost water-tight. The meter case is open only for a moment during replacement of lamps. Life of the lamps ranges from approximately 350 hours at full voltage to more than 12,000 hours at 2.25 volts. For special jobs "aircraft red" lamps also may be obtained.

Transistorized d-c Amplifier. A new advance in direct current amplification is announced by Texas Instruments Inc. with the introduction of the first completely transistorized electronically modulated d-c amplifier for use with the recti/riter *(registered trade mark)* and other milliammeter recorders. The new Model *301* amplifier greatly increases recorder versatility



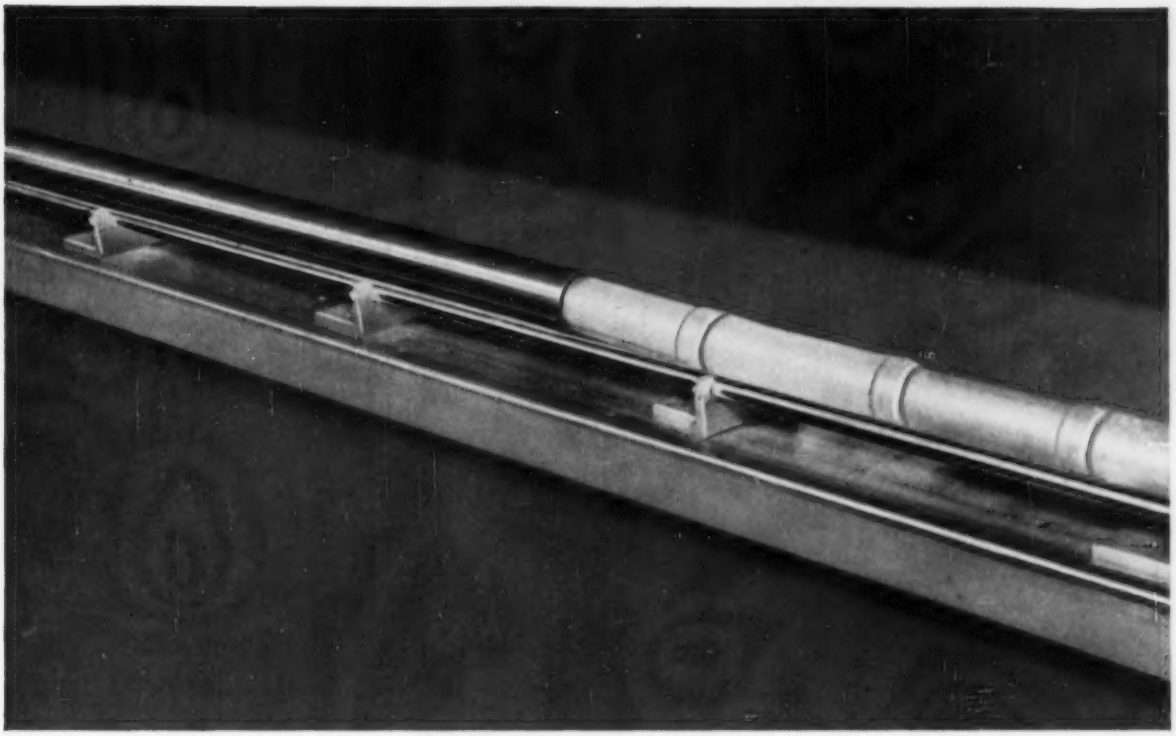
Vernon R. Henriksen Photo

and opens a whole new field for low cost galvanometer recording. Sensitivity of the new instrument is from 10 millivolts d-c to 100 volts d-c full scale in 12 ranges. It has a frequency response up to 50 cycles per second. For further information on the electronically modulated d-c amplifier, write for descriptive bulletin No. *R-503* to Texas Instruments Inc., Industrial Instrumentation Division, 3609 Buffalo Speedway, Houston 6, Tex.

Teflon Cable Clamps. Cable clamps fabricated from Teflon (Du Pont trade mark) give excellent performance under the most severe service conditions. The clamps have superior insulating qualities; they are chemically inert, nonadhesive, and heat resistant over a wide temperature range. The clamps are immune to the effects of weathering and seasonal change even in installations where direct and constant exposure occurs. They offer little friction, and water absorption is rated at zero. For full information, write Weckesser Company, Dept. EGN, 5701 Northwest Highway, Chicago 30, Ill.

(Continued on page 74A)

TOUGH JOB-- WELL DONE!



THE HIGHLY COMPLEX VOICE AMPLIFIER (WHEN COMPLETELY ASSEMBLED) IS PROTECTED BY WOLVERINE COPPER TUBE

NOW! Telephone Calls to London

Routed Via Davy Jones' Locker!

Want to call Number 10 Downing Street?

You will be able to talk to the Prime Minister* from Stateside—direct—as a result of the new trans-oceanic telephone cable that now reaches across the bottom of the Atlantic Ocean. The cable goes smack through Davy Jones' locker and right by King Neptune's throne.

Kidding aside, the story of this cable is a vital one—a tribute to American and British ingenuity. It's a link with Europe that will be there for a long time because of the quality control standards demanded by everyone who had a part in the operation.

For example, Western Electric Company—as builders of the cable's complex voice amplifiers—manufactured each delicate part with the utmost precision—and insisted that components supplied by outside sources undergo the most rugged inspection tests.

One of these components was 1¾ inch outside diameter copper tubing—manufactured by Wolverine Tube—and used to house and protect the complicated voice amplifiers against the ravages of the surrounding salt water.

Before acceptance Western Electric used a microscope to examine the tubing's outside diameter—scanned the gleaming inside surface with a boroscope and tortured sample tubes by stretching them to half again their normal length. The results showed that the Wolverine tubes delivered were probably the finest copper tubes ever drawn. Wolverine is proud of this tubing—but is prouder still of the Tubemanship that made it possible. Next time your company requires tubing or tubular-shaped parts remember that there is a difference in tubing—Tubemanship is that difference.

*Wouldn't do it unless you were in the State Department though

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WOLVERINE TUBE DIVISION
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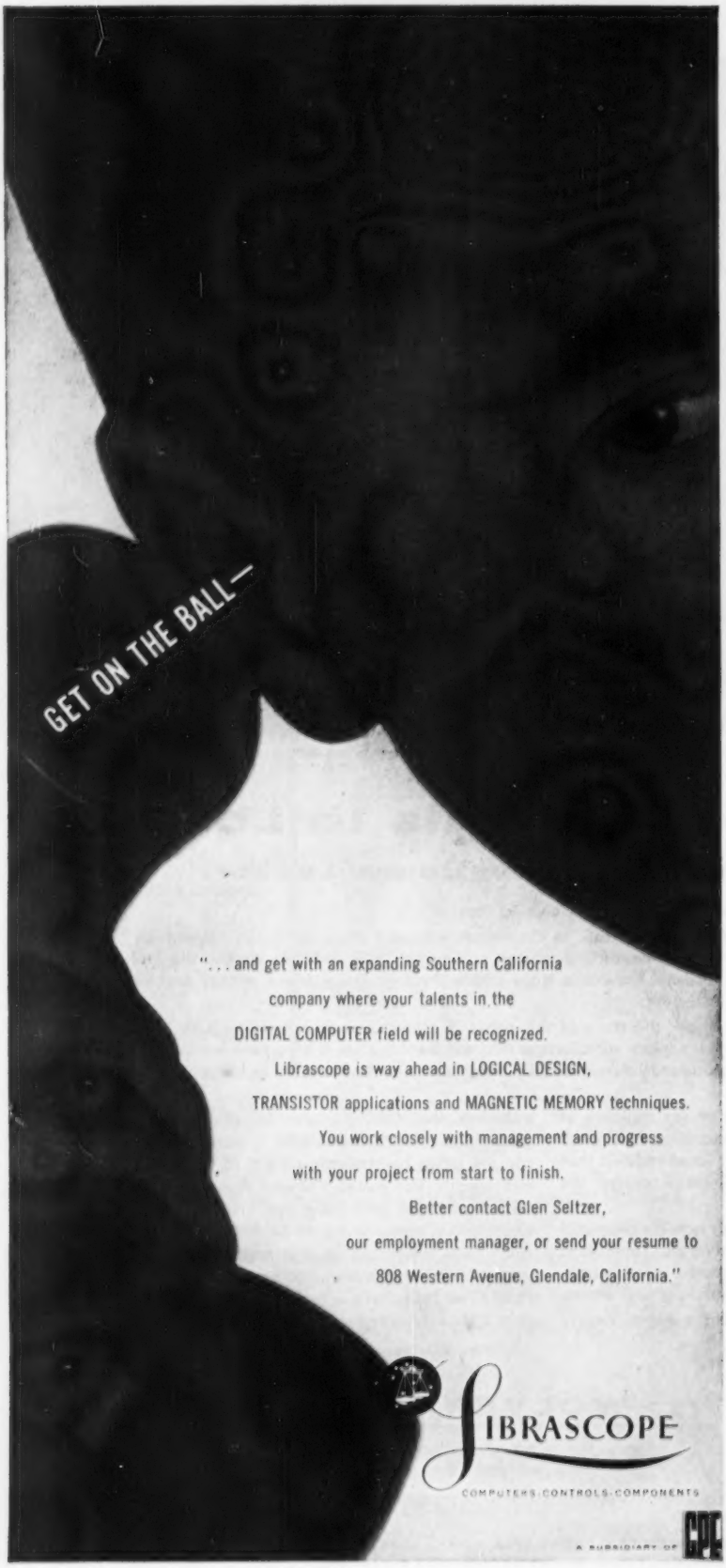
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company where your talents in the
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AIEE TRANSACTIONS

Volume 75 of the 1956 Transactions containing all the technical papers approved by the Technical Committees which were presented during the year is now ready for distribution.

The Transactions are a complete record of advancement in the art of electrical engineering during the year.

This volume in three parts, each bound in cloth, size 8½ × 11½, contains 446 papers, 3,028 pages, including discussions. Each part is separately indexed by subject and by authors. Annual subscription prices are as follows:

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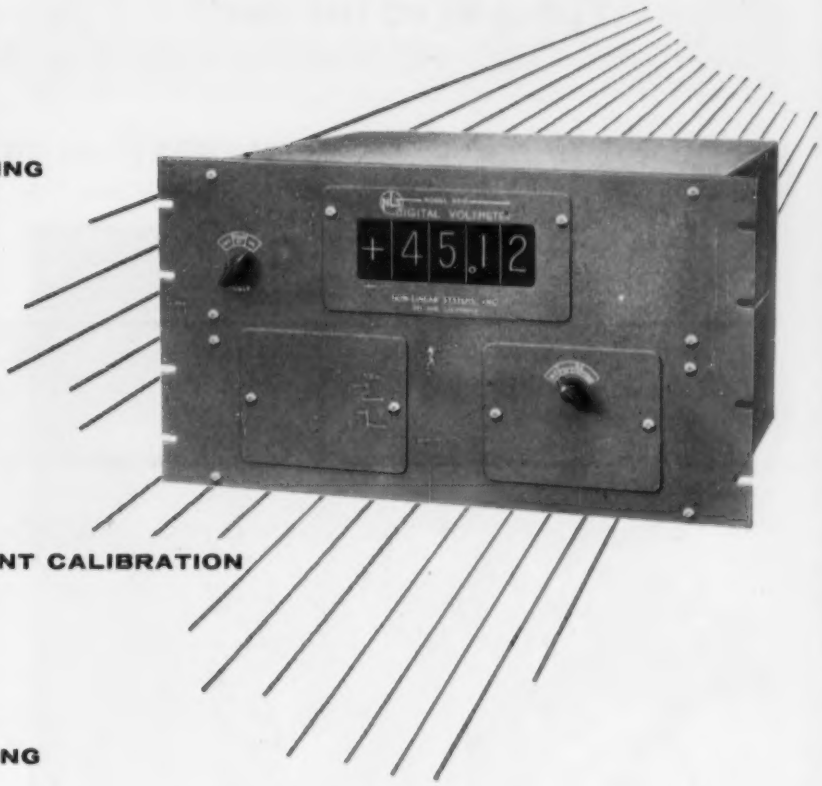
Only **NLS** Digital Voltmeters give you consistent speed and accuracy in...

PRODUCTION LINE TESTING

RECEIVING INSPECTION

LABORATORY INSTRUMENT CALIBRATION

AUTOMATIC DATA LOGGING



HERE is a fully automatic digital voltmeter that embodies all the time-proved features of reliability, accuracy, and read-out speed of the NLS model 451 DC meter PLUS automatic calibration *and* an AC-DC converter. Unskilled personnel can easily read and understand the illuminated 4-digit numerical display of voltages in ranges from 0.001 to 999.9 AC or DC.

Reliability and long life are assured by NLS exclusive oil bath immersed stepping switches. Accuracies are guaranteed to a resolution of one-digit; linearity of .01%; voltage standardization to .02%. The Model 4512 will make precise voltage measurements considerably faster than any other type of measuring equipment—automatically shows DC polarity and automatically changes voltage ranges. Interconnection may be made with other NLS equipment such as input scanners, serial converters and print controls—to fit individual automation system requirements. Automatic data logging systems utilizing Clary printers, Flexowriters, Electric Typewriters, Paper Tape Punches and IBM card punches can be inexpensively adapted to model 4512.

***NLS** is the originator and foremost producer of digital voltmeters with full scale ranges from 10 millivolts to 1000 volts; sensitivity from 1 microvolt up; reading speeds of up to 20 per second; accuracies approaching .01%; up to 6 digit, 1" high illuminated readouts.*

***NLS** Digital Voltmeters and Ohmmeters, Ratiometers, Scanners, and Converters are in volume production and prompt deliveries are assured. Write or wire for complete data.*
***NLS** provides engineering and service facilities in principal cities—coast to coast.*

Originators of the Digital Voltmeter

NLS

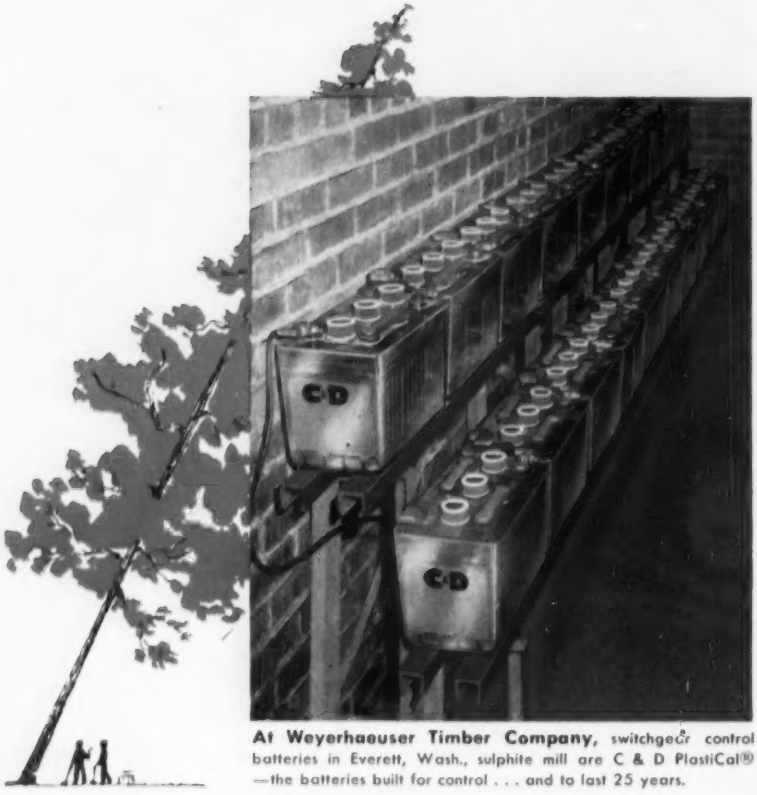
non-linear systems, inc.

San Diego County Airport,
Del Mar, California, Dept. C1057
Sales Engineering Offices
in Los Angeles,
San Francisco,
Phoenix, Cleveland
and Orlando, Fla.

control batteries are built for

25 years of

"packaged power"



At Weyerhaeuser Timber Company, switchgear control batteries in Everett, Wash., sulphite mill are C & D PlastiCal® —the batteries built for control . . . and to last 25 years.

. . . they're C&D PLASTICAL®

Not just "batteries"! These are *engineered* C & D PlastiCal® (lead-calcium) control batteries—batteries specifically designed for switchgear, control, and auxiliary power service —batteries built to deliver high, steady output with only minimum maintenance *for the next quarter-century!*

Weyerhaeuser Timber Co., big suppliers of woodpulp to the paper and allied industries, wanted more than just batteries. Their choice: C & D PlastiCal® —the control batteries with the "more battery for the money advantages."

See why

For details, send for Bulletin CP-536. Find out about the battery of tomorrow—today!

C&D BATTERIES, INC.

of Conshohocken, Pa.

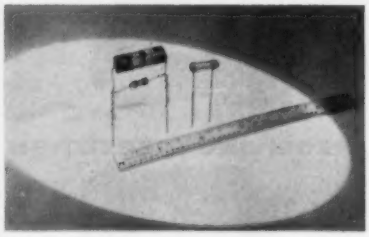
Since 1906

Sales and service offices in principal cities from coast to coast

(Continued from page 70A)

New Products

Resistor-Capacitor Unit. Two new sizes in the Tube-R-Cap, (Registered Trade Mark) a resistor-capacitor unit that requires only the space of a tubular capacitor alone, have been developed and produced. The two sizes are standard sizes *CC20* and *CC25* tubular ceramic capacitors that incorporate, on the same body, a resistor in parallel. The addition of these sizes is intended to increase the vast range of applications of the Tube-R-Cap. These miniature units lend themselves to many



electronic assemblies, and they are described as perfect for antenna line application. The Tube-R-Cap body is impervious to moisture, unaffected by heat, vibration, or common acids. A double coating of Durez phenolic provides insulation. Complete information on the Tube-R-Cap can be obtained by writing Centralab, A Division of Globe-Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.

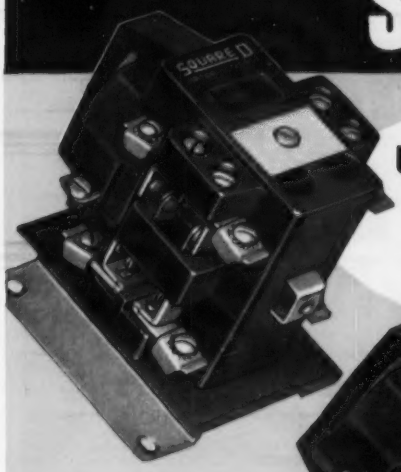
TRADE LITERATURE

High Temperature Insulation Brochure. A new product folder on Micro-Fibers has been published by L. O. F. Glass Fibers Co. Containing descriptions of lightweight micro-quartz and glass microfibers high temperature insulations, the 4-page brochure also lists properties and data on the two products. Copies of brochure *WMF-2* may be obtained by writing to Sales Promotion Department, L. O. F. Glass Fibers Company, 1810 Madison Ave., Toledo 1, Ohio.

Air Engineering Folder. The 24-page Air Engineering Data File (Bulletin *E-57*) covers engineering and test facilities for propeller fans, specifications, construction, maintenance, and installation. Helpful tables for estimating air-handling requirements, entrance and elbow losses, and duct sizes are found in this new folder. Also included are specifications for special-application equipment, such as special propellers, coatings and motors, corrosion-resistance and temperature guides, physical fan laws, terms, and definitions. Aerovent Fan Co., Inc. Piqua 20, Ohio.

(Continued on page 84A)

A COMPLETE LINE OF SPACE-SAVING RELAYS



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2 Normally Open
2 Normally Closed
Measures only
3-5/16" high x 2-5/8" wide!

UP TO 6 CONTACTS
4 Normally Open
2 Normally Closed
Measures only
3-11/16" high x 2-13/16" wide!

NEW!

UP TO 10 CONTACTS
Either 6 Normally Open and
4 Normally Closed or
8 Normally Open and
2 Normally Closed
Measures only
5" high x 3" wide!

- 600 VOLTS • 10 AMPERES • LONG LIFE
- ALL THREE SIZES HAVE IDENTICAL MOUNTING HOLE DIMENSIONS

for the Complete Story, write for Bulletin 8501-D
Square D Company, 4041 N. Richards Street, Milwaukee 12, Wis.

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SQUARE D COMPANY

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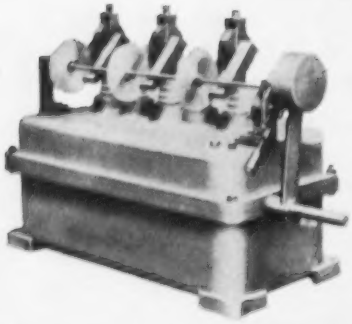
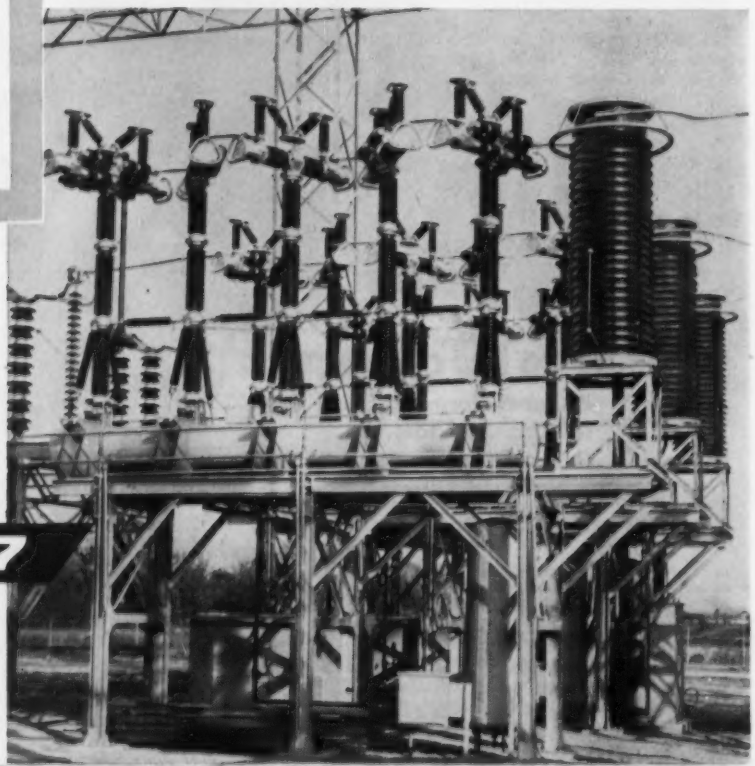
1st in BREAKER DESIGN

1898

The first oil circuit-breaker in practical service.





1957

The world's largest airblast breaker, 345 kV.

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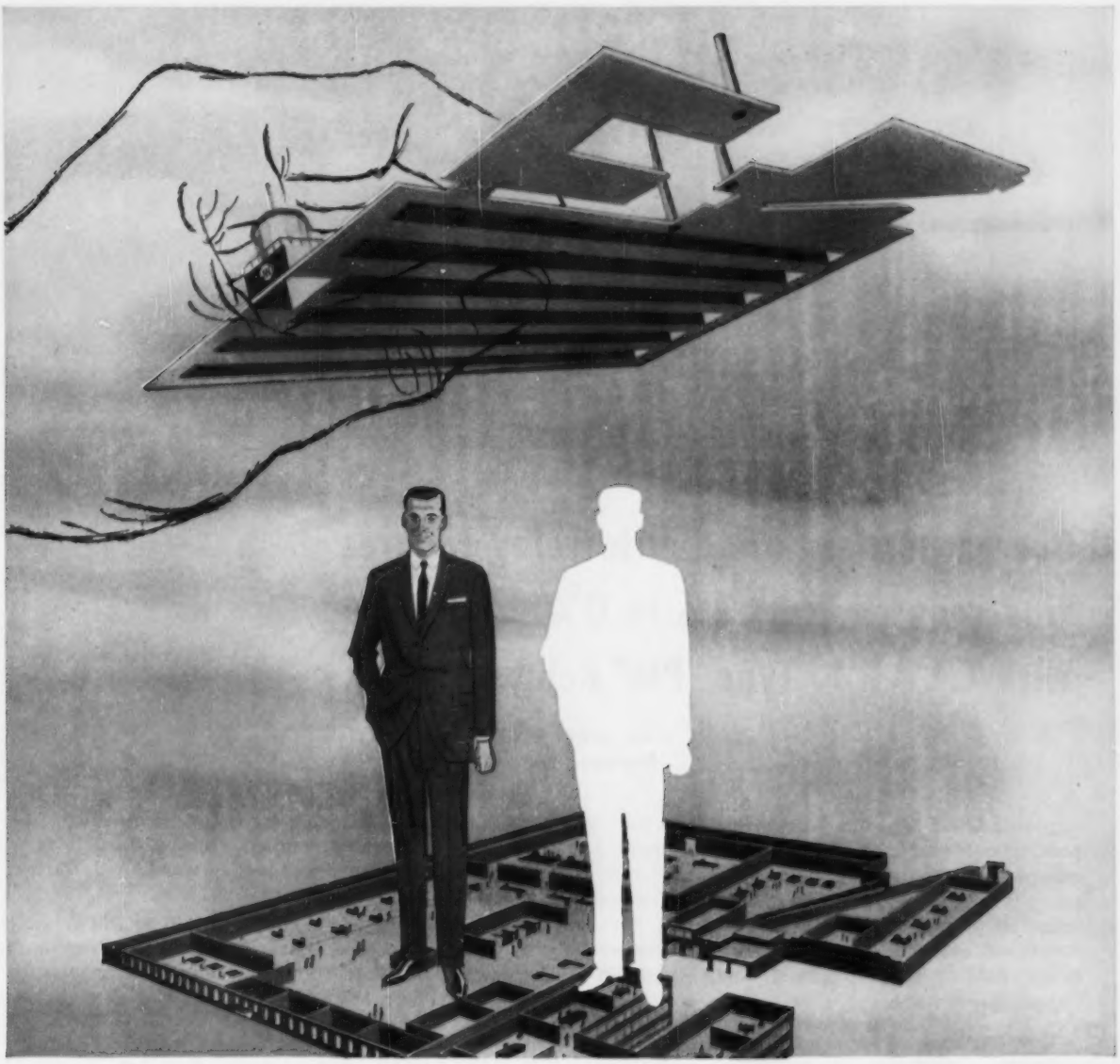

We give you a partner, when your project's under this roof

When you invite us to develop and produce aircraft systems or equipment, we immediately assign a top man to get you what you want and need.

He goes direct . . . pares away time . . . deals in a straight line with our engineers, production personnel and any others who can contribute to the success of your project.

Suppose, for example, a change in aircraft specs comes in, after production's under way. It calls for a new systems design. Your "partner" (Project Manager) acts immediately. Stops production. Implements engineering changes. Unravels any knotty problems up and down the line. So in minimum time, the *new* design is up to top-speed production.

Our Project Managers are one more reason why *under one roof* Jack & Heintz produces the widest range of aircraft electric systems and equipment available from any single source.

We invite your inquiry. Write Jack & Heintz, Inc., 17622 Broadway, Cleveland 1, Ohio.

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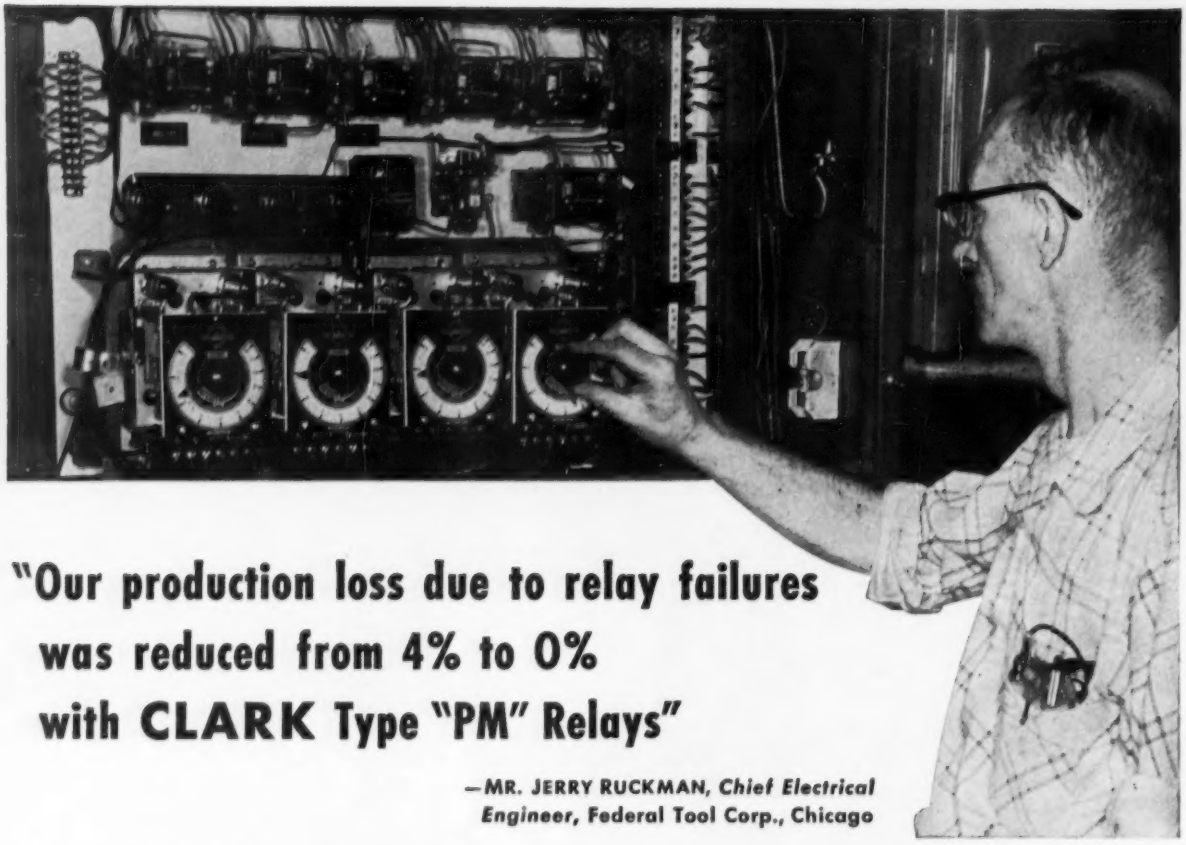


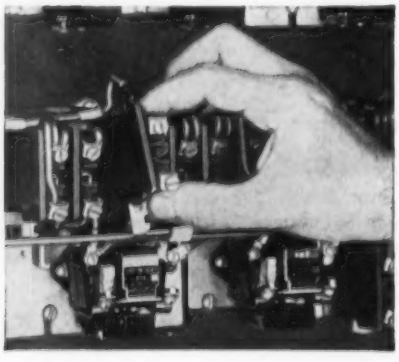
"Our production loss due to relay failures was reduced from 4% to 0% with CLARK Type "PM" Relays"

—MR. JERRY RUCKMAN, *Chief Electrical Engineer*, Federal Tool Corp., Chicago

Explains Chief Engineer Ruckman: "We turn out plastic housewares, haircurlers, toys, premiums and other plastic products by the hundreds of thousands every twenty-four hours. Demand is high. Customers insist on prompt delivery. That's why we were so concerned over the erratic operation of the relays in our molding machine control panels—the heart of our production line.

"We found that non-conductive plastic dust was collecting on the relay contacts, causing them to fail. When this happened, production was halted. Losses amounted to four percent.

"Two years ago we installed Clark Type PM relays, in which each set of contacts is shielded by its own melamine housing. Production stoppages from plastic dust have been cut to zero."



The unique sectional pole construction of the Clark Type "PM" relay offers many other important advantages

Compact, it's a space-saver. Rugged, it has built-in protection against vibration damage. Simple, it is easy to install and service. Each pole is a self-contained unit that can be removed, installed or replaced without disturbing the others. All terminals are in front for easy accessibility. Each pole has its own individual arcing chamber—a short circuit through one set of contacts is confined to a single pole, and will not destroy the entire relay.

The **CLARK CONTROLLER** *Company*

Everything Under Control **1146 East 152nd Street • • Cleveland 10, Ohio**

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

Imagination!

. . . fired by an atmosphere of enthusiasm and progress, is reflected in the all-new B-58—latest achievement of the team of engineers and scientists at CONVAIR-*FORT WORTH*, America's first supersonic bomber, and another "first" from Convair. But for the scientist and the engineer at CONVAIR-*FORT WORTH*, still newer and more stimulating projects await his imagination and ingenuity in the nearly half-a-hundred Air Force contracts now on hand. He feels confident of success, for there is a wealth of talent to complement his efforts, and no lack of technical facilities to expedite his work.

And there is more, for his family enjoys a mild climate year 'round, countless recreational facilities, modern metropolitan educational and cultural benefits. The cost of living is low, and there's no state sales or income tax, which means his money goes further . . . that's *important*, too!

You're invited to investigate the opportunity awaiting *you* at CONVAIR-*FORT WORTH*. Your inquiry is confidential, of course.

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MR. H. A. BODLEY

Engineering Personnel Dept. 6

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FOR IMMEDIATE DELIVERY FROM STOCK

BAND PASS FILTERS

Catalog No. $Z_s = 500\ \Omega$	Catalog No. $Z_s = 2,500\ \Omega$	3DB Bandwidth per cent of F_o ± 9½	± 19½	Center Frequency F_o (KC)
FBP-10	FBP-34	√		4
FBP-11	FBP-35	√		56
FBP-12	FBP-36	√		73
FBP-13	FBP-37	√		96
FBP-14	FBP-38	√		1.3
FBP-15	FBP-39	√		1.7
FBP-16	FBP-40	√		2.3
FBP-17	FBP-41	√		3.0
FBP-18	FBP-42	√		3.9
FBP-19	FBP-43	√		5.4
FBP-20	FBP-44	√		7.35
FBP-21	FBP-45	√		10.5
FBP-22	FBP-46	√		12.3
FBP-23	FBP-47	√		14.5
FBP-24	FBP-48	√		22.0
FBP-25	FBP-49		√	22.0
FBP-26	FBP-50	√		30.0
FBP-27	FBP-51		√	30.0
FBP-28	FBP-52	√		40.0
FBP-29	FBP-53		√	40.0
FBP-30	FBP-54	√		52.5
FBP-31	FBP-55		√	52.5
FBP-32	FBP-56	√		70.0
FBP-33	FBP-57		√	70.0

DISCRIMINATORS

Per cent Deviation of F_o 6½	15.	Per cent Linearity 0.5	1.0	Catalog No.
√		√		DST-10
√		√		DST-11
√		√		DST-12
√		√		DST-13
√		√		DST-14
√		√		DST-15
√		√		DST-16
√		√		DST-17
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√		√		DST-20
√		√		DST-21
√		√		DST-22
√		√		DST-23
√		√		DST-24
	√		√	DST-29
√		√		DST-25
	√		√	DST-30
√		√		DST-26
	√		√	DST-31
√		√		DST-27
	√		√	DST-32
√		√		DST-28
	√		√	DST-33

DISCRIMINATOR LOW PASS FILTERS

Catalog No.	Center Frequency F_o (cps)	Catalog No.	Center Frequency F_o (cps)	Catalog No.	Center Frequency F_o (cps)	Attenuation
OUTPUT						
LPO-10	6	LPO-19	81	LPO-28	790	
LPO-11	8	LPO-20	110	LPO-29	900	
LPO-12	11	LPO-21	160	LPO-30	1,050	
LPO-13	14	LPO-22	185	LPO-31	1,200	
LPO-14	20	LPO-23	220	LPO-32	1,600	
LPO-15	25	LPO-24	330	LPO-33	2,100	
LPO-16	35	LPO-25	450	LPO-34	2,200	
LPO-17	45	LPO-26	600	LPO-35	10,000	
LPO-18	60	LPO-27	660			
Characteristic impedance of all 330Ω						2 DB to 0.5 F_o 7 DB to 1 F_o 20 DB to 2 F_o 30 DB from 2.5 F_o
INPUT						
LPI-10	400	LPI-17	2,000	LPI-23	14,500	
LPI-11	560	LPI-18	2,900	LPI-24	22,000	
LPI-12	730	LPI-19	5,400	LPI-25	30,000	
LPI-13	960	LPI-20	7,350	LPI-26	40,000	
LPI-14	1,300	LPI-21	10,500	LPI-27	52,500	
LPI-15	1,700	LPI-22	12,300	LPI-28	70,000	
LPI-16	2,300					
Characteristic impedance of LPI-10 thru 23 — 30,000Ω of LPI-24 thru 28 — 5,100Ω						.05 DB at 9½ % F_o 20 DB at third 30 DB at fifth Harmonics

Write for detailed information on these and other components for military and commercial applications. Send for NEW 48 page TRANSFORMER CATALOG. Also ask for complete LABORATORY TEST INSTRUMENT CATALOG.

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Will Tell You!

Scam sequential annunciator systems provide an audible and flashing visual signal on the first alarm to enable the operator of your control board to determine which point in the monitored process first becomes abnormal . . . successive alarms that develop from the original abnormal condition are indicated by a steady visual signal. You can take proper corrective measures immediately because you know where the trouble started.

Shown here is a typical standardized Scam DE-LINE cabinet with integral flasher and reset pushbutton, featuring all the Scam advantages including simple, compact plug-in design.

If you've a process or system that needs automatic, fail-safe, low cost monitoring write us for literature or call the nearest representative in the cities listed below.

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Phone GRaceland 7-7850
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and Vancouver, Canada

MEASUREMENTS'
MEGACYCLE METER— extended coverage from 100 Kc to 940 Mc

Determines resonant frequency of tuned circuits, antennas, transmission lines, by-pass condensers, chokes, etc. Measures inductance and capacitance. Also used as a signal generator, wave meter, frequency meter, and in many other applications.

This compact, light-weight grid-dip meter is available in the following frequency ranges:

Model 59-LF	**100 Kc to 4.5 Mc**
Model 59	**2.2 to 420 Mc**
Model 59-UHF	**420 to 940 Mc**

Laboratory Standards

MEASUREMENTS CORPORATION
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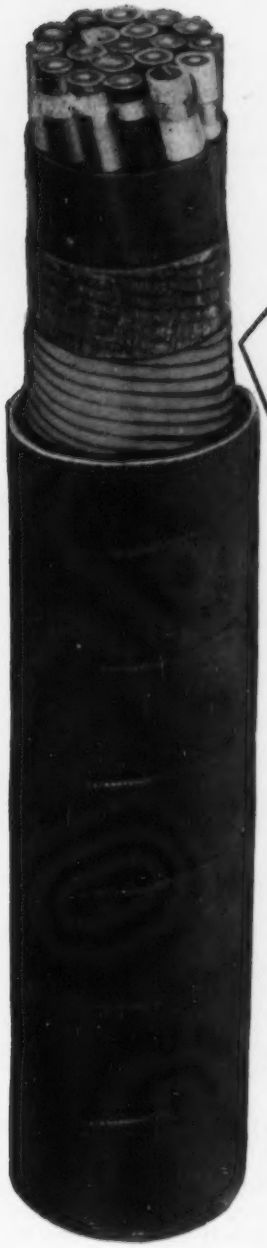


this feature of CM-OT provides light weight and unusually high compressive strength

It's the corrugated bronze tape that makes CM-OT particularly suitable for direct burial power and control circuits. It provides a cable that is light weight, has high compressive strength, and whose cost approximates standard rubber-insulated, neoprene-sheathed cables. In addition, the bronze tape serves as an excellent shield and ground for control cable circuits in those utility and industrial applications where these are considered desirable.

The CM-OT sheath consists of a 5-mil, helically-wrapped, corrugated bronze tape . . . a wall of Okoprene reinforced with an Okoprene-filled cable tape . . . and an outer wax and mica lubricated finish. While primarily designed for multi-conductor signal and control cables, the CM-OT sheath can be supplied over single and multi-conductor power cables with conductor sizes as large as #4/0 Awg.

Here are just some of the basic direct burial installation requirements that CM-OT meets: resistant to earth pressures, water, corrosion, electrolysis, fungi, insects and small rodents, lightning surges and extremes of temperature. It is flexible and easy to handle, splice and terminate with conventional tools . . . can be installed in long lengths (1500-2500 feet or longer) . . . adaptable for aerial, underground duct, rack or conduit installations . . . long life and reliability.

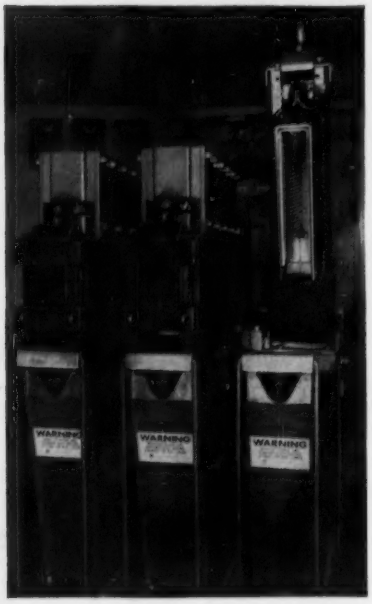
For more complete details, write for Bulletin EG-1086 to The Okonite Company, Passaic, N. J.

where there's electrical power . . . there's **OKONITE CABLE**

4741

METAL-CLAD SWITCHGEAR

PURIFIED PORCELAIN in horizontal and vertical bus supports, primary disconnect bushings and caps and epoxy in bus joint covers provide excellent insulation, prevent fires in 15 kv I-T-E metal-clad switchgear. ◀



▲ **EPOXY AND SPECIAL CERAMICS** protect personnel and equipment by preventing fires in the circuit breaker section. Arc chute rear supports and blowout coils are epoxy. Jump gap cooling plates, arc chute liner plates, arc plates and spacers are special ceramics.

Only the finest fire-protective insulating materials

Nonflammable porcelain and ceramics, flame-resistant epoxy, and other flame-retardant insulating materials throughout, are among the extra values you find in I-T-E Metal-Clad Switchgear. Purified porcelain, of which the primary disconnect bushings and caps are made, also supports both vertical and horizontal bus. It is nonflammable, has high dielectric strength, won't track or deteriorate, is inherently contamination free.

Epoxy, which can be molded into complicated shapes, forms arc chute rear supports, blowout coils, bus joint covers, potential and current transformers. It has high mechanical and dielectric strength, is nontracking and extremely flame resistant.

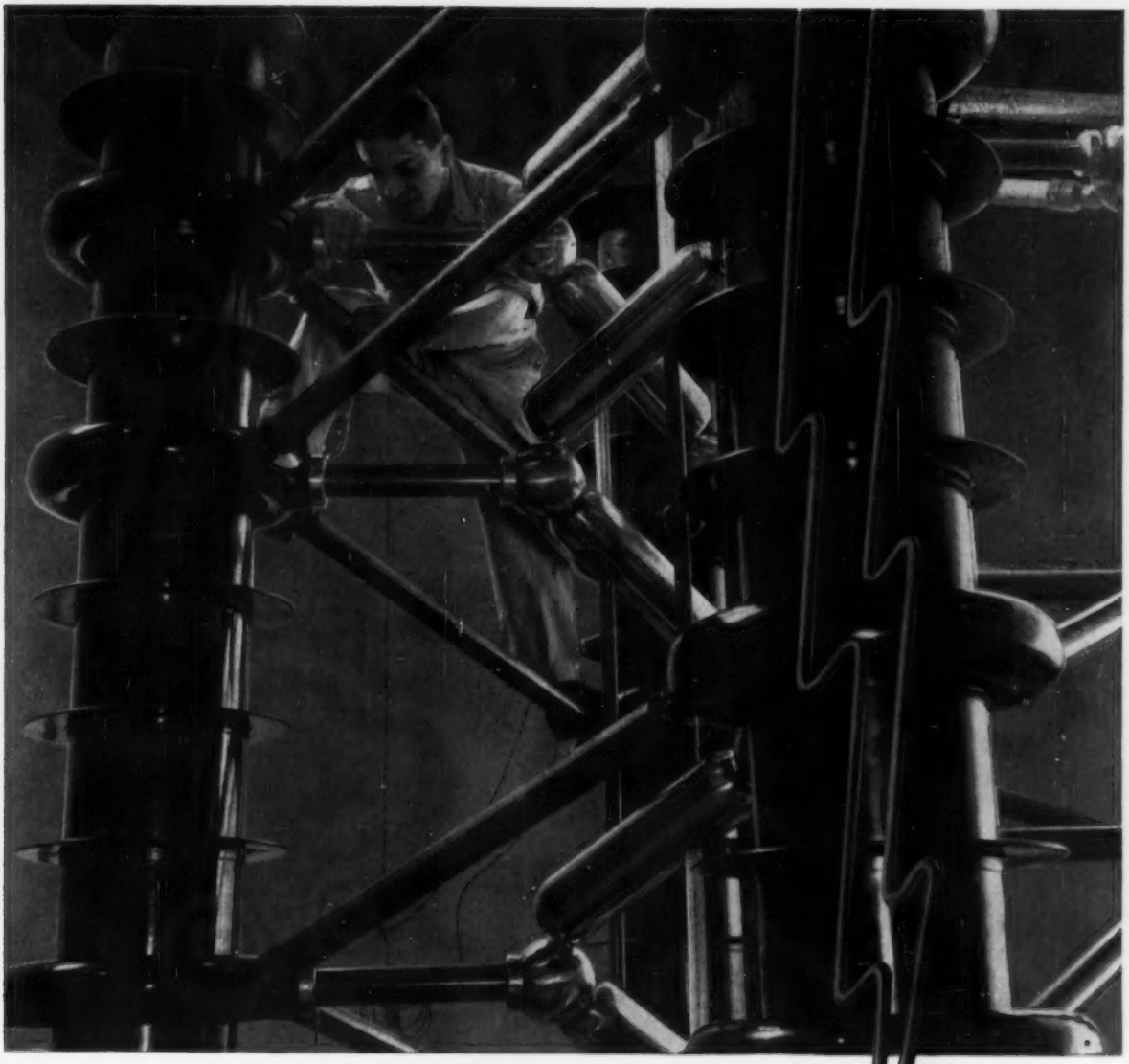
Special ceramics, highly resistant to direct arc exposure, are used in jump gap cooling plates, arc chute liner plates, arc plates and spacers. These have high dielectric strength, low moisture absorption, won't track, are excellent interrupting materials. They do not deteriorate when subjected to direct arc exposure. They absorb thermal shock and deionize gases without excessive heating.

Phenolic and polyester insulating sheets and moldings, specially treated to provide the highest possible degree of flame-retardant characteristics, are also used.

If you are planning new construction or modernization requiring electric power, consider the advantages of I-T-E equipment. Consult your local I-T-E sales office or write I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Philadelphia 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY • Switchgear Division

IN CANADA: EASTERN POWER DEVICES, LTD.



Simplex Wire & Cable Company's new 1,400,000 volt impulse generator — the first of its kind to be installed in North America — represents just one aspect of research at Simplex. Simplex scientists and engineers originated the process of vulcanizing portable rubber cords and cables in a lead mold. Simplex developed the first heavy-duty portable electrical cable — Simplex TIREX. The first truly moisture-resistant rubber insulation was the outcome of a commercially acceptable method of deproteinization developed by Simplex. Simplex designed the first interlocked armored cable for underground service — Simplex CONDEX. And now — Simplex C-L-X — the portable, corrugated metallic duct WITH SEALED-IN CABLE. **SIMPLEX WIRE & CABLE CO.,** Cambridge, Massachusetts and Newington, New Hampshire.

Simplex

Highest quality cables for: Mining • Power & Lighting • Construction • Transportation • Communications • Signalling

A Radical New Approach!

TO DIFFICULT SWITCHING REQUIREMENTS

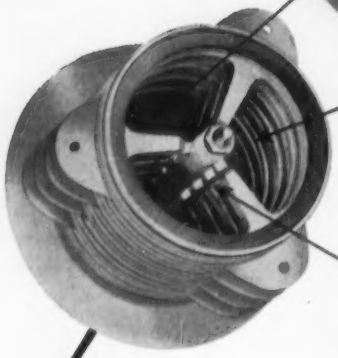
CERAMIC VACUUM RELAYS

by Jennings

Vacuum Enclosure

Insures Clean Contacts that stay clean at dry circuit levels.

Reduces Contact Arcing and Pitting at high currents.



Stacked Ceramic Construction

Permits Small, Compact Design that insures reliable performance under extremes of vibration, temperature, and shock.

Three Sets of Parallel Contacts

Increase Reliability because three relays in parallel are more reliable than one.

Decrease Bounce Time to less than 100 μsec.

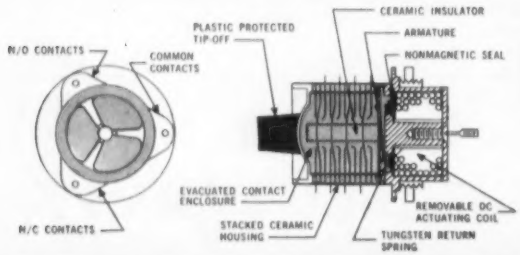
Increase Make Current to 100 amperes inrush because contacts are not bouncing and arcing.

Increase Contact Life when interrupting currents up to 15 amperes at 28 vdc or 2 amp at 300 vdc.

(Heavy duty contacts will interrupt up to 60 amps at 28 vdc)

This revolutionary new vacuum relay has been fully tested and is available in production quantities.

Send for catalog literature on SPDT and 4PDT Type RA relays.



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(Continued from page 74A)

Trade Literature

Insulation Prices Manual. Net prices for pipe insulation can be read directly from tables in the 28-page "Manual of Plus Values" recently published by Union Asbestos & Rubber Company, 1111 West Perry St., Bloomington, Ill. No computation is needed. Beginning with a table of list prices for the 186 basic sizes and thicknesses of insulation, this handy manual then presents 50 tables showing the net prices for these same items using from 1 to 50% plus discount. Any one of 9,300 net prices is found by a simple cross-reference to insulation thickness and pipe size on the proper table for the desired plus value. Users and distributors of insulation may secure free copies of the "Manual of Plus Values" by writing on their business letterhead to the company.

Distribution Transformer Bulletin. A 16-page bulletin, "Distribution Transformers for Rural and Industrial Substations" (75 through 500 kva, 67 kv and below, single phase), has been released by Allis-Chalmers Manufacturing Company, Milwaukee 1, Wis. The bulletin describes the materials and various steps used in producing this type of transformer. It includes a complete summary of weights and dimensions along with outline drawings, and Edison Electric Institute–National Electrical Manufacturers Association standard accessories for the various sizes. Copies of the bulletin, *61B6014C*, are available on request from the company.

Film Catalog. A booklet entitled "Westinghouse Sound Films" has been made available. The booklet is a catalog of 47 general-interest films, product information films, and training films. The 16-mm sound films are for use by church, social, professional, civic, and business groups. Also included is a description of instruction courses available to electric utility companies. For a free copy of booklet *B-7077* write, Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, Pa.

Surface Raceway Bulletin. Twinduct electrical surface raceway, manufactured by National Electric Products Corporation, is reviewed in an illustrated 4-page bulletin published for architects, engineers, electrical contractors, home builders, and other specifiers of electrical equipment. Twinduct is described as a modern dual-service electrical distribution system comprised of two runs of metal duct under a single screw-type cover. It is produced with ½-inch and ¾-inch knock-outs and mounting holes located on 15-inch centers. With the common removable cover, runs are shown as easily accessible to accommodate lay-in wiring for power, light, telephone, and intercommunication facilities. Copies of the new Twinduct folder can be obtained by writing National Electric Products Corporation, Two Gateway Center, Pittsburgh, Pa.

(Continued on page 86A)

In Engineering,
THE BEST OPPORTUNITIES
are in Aviation

In Aviation,
THE BEST OPPORTUNITIES
are at TEMCO

ELECTRONICS ENGINEERS
To perform research, development and design on antennae, radomes, microwave components, radar, transponder systems, pulse and video circuits, servo-mechanisms, guidance systems, audio circuits, pulse and timing, computer and switching.

DEVELOPMENT LABORATORY ENGINEERS
Expanding programs in Instrumentation, Environmental, Servo, Structures, Hydraulics, Antenna and Radio Frequency Engineering laboratories are creating exceptional growth opportunities.

DESIGN ENGINEERS
Missile and aircraft prime contracts are requiring Senior Designers in Hydraulics, Support Equipment, Electromechanical, Packaging, Test and Checkout Equipment and Electrical Equipment Installation Design groups.

STRUCTURES ANALYSIS ENGINEERS
Assignments on both missile and aircraft programs in Structural Methods, Structural Loads and Structural Analysis groups. Also unusual opportunities for Senior Weights Engineers in Analyses and Methods groups.

TEMCO
AIRCRAFT CORPORATION, *Dallas, Texas*

MR. JOE RUSSELL, Engineering Personnel
Dep't 170-B, Room 9, Temco Aircraft Corp.
Box 6191, Dallas, Texas

Please send me complete details of the Temco story of unusual opportunities for creative engineers. I am especially interested in

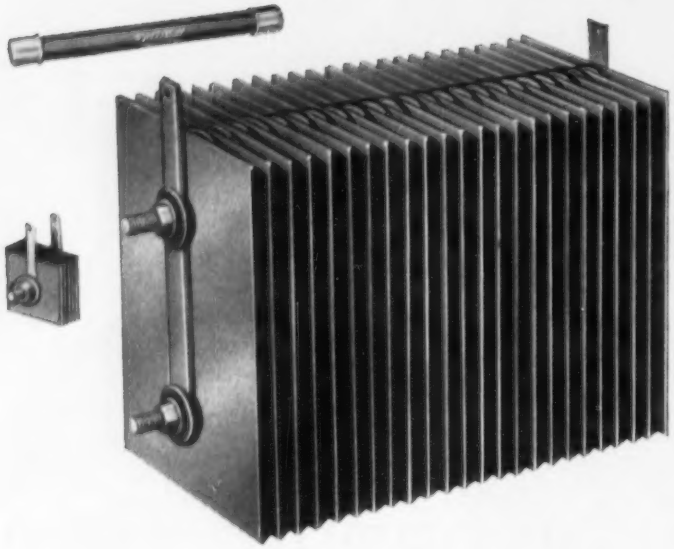
NAME

ADDRESS

CITY STATE

SYNTRON **VACUUM PROCESS**

SELENIUM RECTIFIERS



Proven by Years of dependable, Quality Performance

Syntron's unique vapor deposit process, quality control methods, and construction design provide rectifiers of extreme uniformity, and ruggedness. Their low forward voltage drop means longer life and lower operating temperature. They have high short circuit surge-current ability to 300 times their normal rating and can withstand high transient conditions without damage.

Syntron builds the largest variety of selenium cell sizes in the world. This permits Syntron to build single rectifier stacks to specifications. Eliminates the use of several smaller stacks in a series hook-up. Let our applications engineers recommend the best rectifier for you. Write for complete data—FREE

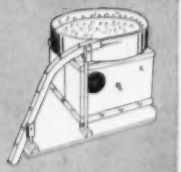
Builders of Quality Equipment for more than a Quarter-Century.

Other SYNTRON Equipment of proven Dependable Quality

AC TO DC POWER CONVERSION UNITS

SINUATED WIRE

PARTS FEEDERS



Write for complete catalog data — FREE

SYNTRON COMPANY
440 Lexington Avenue **Homer City, Penna.**

(Continued from page 84A)

Trade Literature

Bulletin on Stainless Steel Hinges. A bulletin has been issued listing stainless steel hinges now carried in stock by Star Stainless Screw Company, 655 Union Blvd., Paterson 2, N.J. Covering more than 30 different sizes in continuous or piano-type stainless steel hinges as well as butt hinges, fixed pin type, and loose pin type. The bulletin shows length, gauge, pin, joint, and open width measurements. Plain or countersunk holes will be made to specifications furnished, and changes in given dimensions within certain limitations can be made. Copies of the new bulletin on stainless steel hinges as well as Star's Catalog of Stainless Fastenings, 1957 Edition are available from the company.

Image Intensification Fluorescopy. A 6-page folder which describes modern techniques for applying electronic fluoroscopy in metal examinations, is available gratis from the Instruments Division, Philips Electronics, Inc., 750 South Fulton Ave., Mount Vernon, N.Y. Reprinted from the March-April 1957 issue of *Non-Destructive Testing*, the article tells how to handle thick steel and aluminum sections, discussses automation possibilities briefly and is well-illustrated with photos, drawings, and graphs.

Guide for Selecting Engineering Firm. Practical advice on the selection of an engineering firm is available in a newly revised brochure being offered. Developed in the interest of good management practice, the brochure, entitled "A Guide for Selecting an Engineering Firm," answers in detail three basic questions asked by companies having engineering problems: Do we need an engineering firm? Whom should we choose? What results can we expect? Copies of this enlightening brochure can be obtained by writing the Teller Company, Butler, Pa.

Electric Generating Plants "Blue Book." D. W. Onan & Sons Inc., 2600 University Ave., S.E., Minneapolis 14, Minn., has revised their Blue Book of general information concerning the selection of engine driven electric generating plants. The pocket sized booklet traces the history of electric plant development from early stages where storage batteries were necessary to today's modern single-unit, engine-generator power plants. Described in simple language are the three general groups of electric plants: alternating current, direct current, and battery charging. Plant operation for each type is thoroughly discussed. Copies are available by writing the manufacturer. Ask for the Blue Book.

Electric Disk Brake. An 8-page, 2-color brochure on the redesigned Star-Kimble Series *E* Electric Disk Brake line completely describes and illustrates outstanding new features. Star-Kimble Industrial Motor Division, Safety Industries, Inc., P. O. Box 904, Hamden, Conn.

(Continued on page 90A)

Do you worry about power distribution problems

AT 3:00 A. M.?

If you have a power distribution system problem — either in an old building or in that new one you're planning — here's one way you can stop losing sleep over it. Just use Rockbestos A.V.C. (asbestos, varnished-cambric insulated) Interlocked Armored Cable. It will help you cut costs and at the same time assure you dependable service. Here's why:

- Rockbestos A.V.C. Interlocked Armored Cable gives you more current capacity than cable in conduit or other armored cable. Single conductors are standard N.E.C. Type AVA power cables.
- You save important dollars by eliminating the need for costly conduit or ducts.
- It's easily installed on racks or hangers beneath the ceiling or next to walls.
- It can be installed up, down or around walls, beams or posts.
- It cuts installation time and permits quick, easy repairs.

Get all the details on Rockbestos A.V.C. Interlocked Armored Cable — Write now for catalog which gives complete specifications and application data.

ROCKBESTOS PRODUCTS CORPORATION

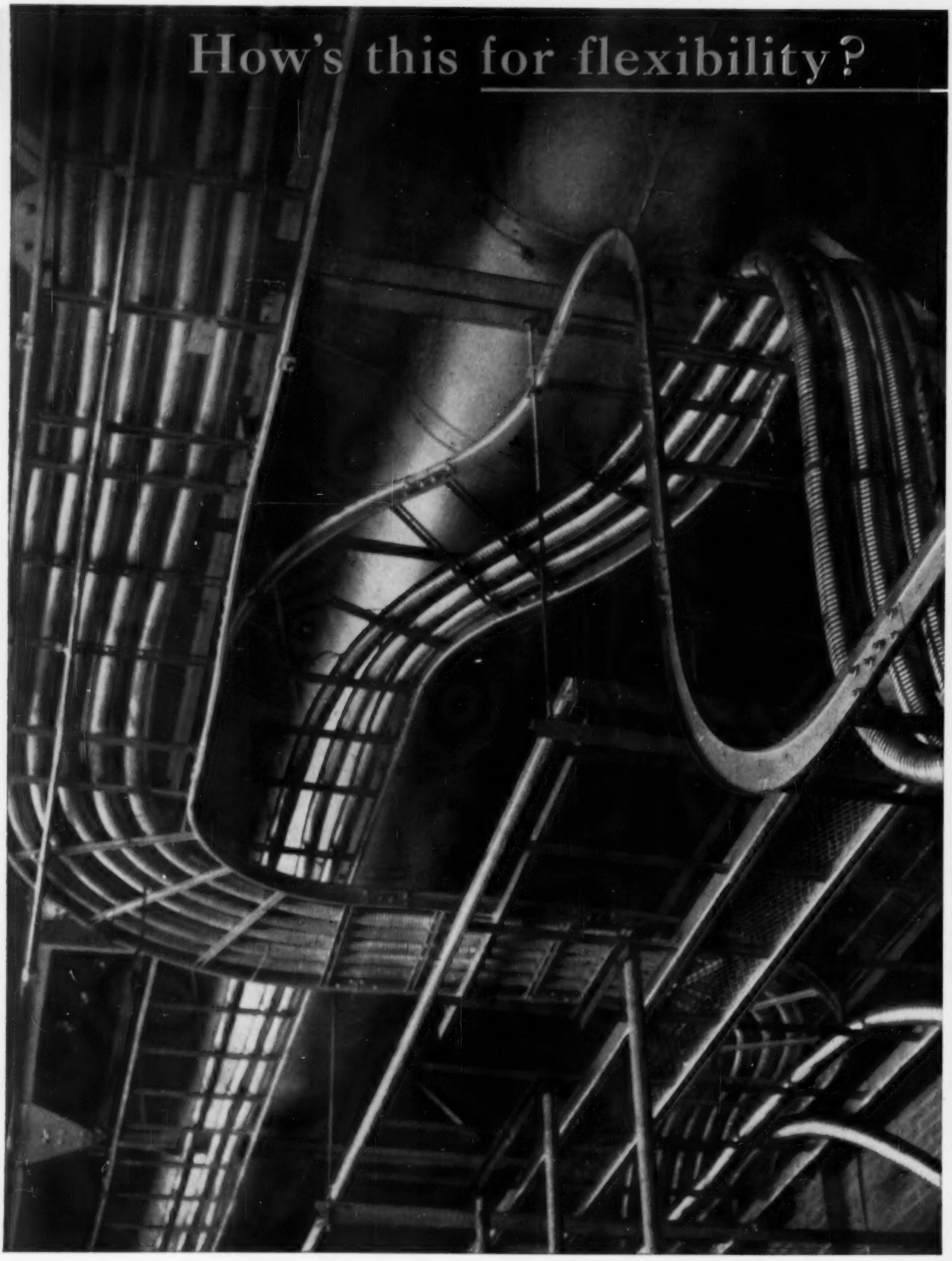
NEW HAVEN 4, CONNECTICUT | NEW YORK, CLEVELAND, DETROIT, CHICAGO, PITTSBURGH, ST. LOUIS, LOS ANGELES, NEW ORLEANS, OAKLAND, SEATTLE

ROCKBESTOS

A. V. C. Interlocked Armored Cable

For New Buildings, Expanding Existing Circuits, Relocating Old Circuits

How's this for flexibility?



Design for the future NOW with Tiger Brand Armorlokt

BETTER THAN WORDS, the big picture shows the complete flexibility of Tiger Brand Armorlokt when installed in an open rack system. New cables can be added easily *any time* when your electrical load increases . . . as it surely will in the years to come.

Remember the splicing advantages of this cable, too. It's not likely, but if Armorlokt is damaged by a crane or some other object, you simply insert a splice box. Compare this to cable in rigid conduit; if it's damaged, you have to pull the entire cable out (if you can *get* it out) and start all over.

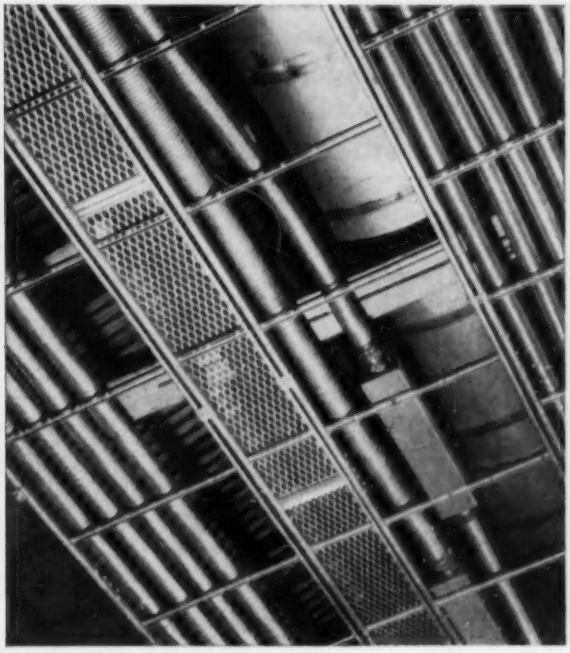
If you want to look to the future while designing today, think seriously about Tiger Brand Armorlokt for new construction or modernization. It is made in a complete range of sizes and constructions. Just ask your AS&W salesman.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors

Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, New York

Flexible Armorlokt eliminates strain at boxes.



Splices can be made anywhere along cable.

Watch the **United States Steel Hour** on TV every other Wednesday (10 p.m. Eastern time).

USS TIGER BRAND ELECTRICAL WIRE & CABLE

A STANDARD TIGER BRAND CABLE FOR EVERY SPECIAL JOB

- ASBESTOS WIRE AND CABLE
- MOLD CURED PORTABLE CORD
- SHOVEL & DREDGE CABLE
- PAPER & LEAD CABLE
- VARNISHED CAMBRIC CABLE
- INTERLOCKED ARMOR CABLE
- SPECIAL PURPOSE WIRE & CABLE
- AERIAL, UNDERGROUND AND SUBMARINE CABLE

USS TRADEMARK

UNITED STATES STEEL

TELEPHONE AND TELEGRAPH EQUIPMENT

Radio Engineering Products is currently producing a number of types of equipment, electrically and mechanically interchangeable with standard Bell System apparatus.

CARRIER-TELEPHONE EQUIPMENT

C5 Carrier-Telephone Terminal (J68756). A kit for adding a fourth toll-grade channel to existing C systems is available. • C1 Carrier-Telephone Repeater (J68757) • 121A C Carrier Line Filter • H Carrier Line Filter (X66217C).

CARRIER-TELEGRAPH EQUIPMENT

40C1 Carrier-Telegraph Channel Terminal (J70047C) • 140A1 Carrier Supply (J70036A1, etc.) • 40AC1 Carrier-Telegraph Terminal.

VOICE-FREQUENCY EQUIPMENT

V1 Telephone Repeater (J68368F) • Power Supply (J68638A1) • V1 Amplifiers (J68635E2 and J68635A2) • V3 Amplifier (J68649A) • V-F Ringers (J68602, etc.) • Four Wire Terminating Set (J68625G1) • 1C Volume Limiter (J68736C).

D-C TELEGRAPH EQUIPMENT

16B1 Telegraph Repeater (J70037B) • 10E1 Telegraph Repeater (J70021A) • 12B82 Teletypewriter Subscriber Set (J70027A).

TEST EQUIPMENT

2A Toll Test Unit (X63699A) • 12B, 13A, 30A (J64030A) and 32A (J64032A) Transmission Measuring Sets • 111A2 Relay Test Panel (J66118E) • 118C2 Telegraph Transmission Measuring Set (J70069K) • 163A2 Test Unit (J70045B) • 163C1 Test Unit (J70045D).

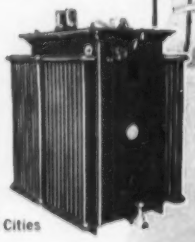
COMPONENTS AND ACCESSORIES

255A and 209FG Polar Relays • Repeating and Retard Coils, several types • 184, 185, 230A and 230B Jack Mountings.

RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY ST., MONTREAL 3, CANADA
TELEPHONE University 6-6887 CABLES RADENPRO, MONTREAL

The New GOLDEN GATE in Miami Beach transforms a vacation into an event.

And for the finest in transformer value, this famous resort uses MARCUS for power and lighting distribution. You, too, can guarantee trouble-free performance and a real vacation from maintenance and replacement problems by specifying MARCUS for your next transformer installation.



MARCUS
TRANSFORMER CO., Inc.
RAHWAY, NEW JERSEY

"Mark of Quality"

Representatives in Principal Cities

A COMPLETE LINE OF DRY TYPE AND LIQUID-FILLED TRANSFORMERS THRU 5000 KVA

(Continued from page 86A)

Trade Literature

Ballast Bulletin. A 16-page catalog and selection guide covering the company's complete line of fluorescent lamp ballasts is available from the General Electric Company (GE), Schenectady 5, N. Y. Designated *GEC-983K*, this illustrated bulletin contains a listing of obsolete ballasts and suggested replacements for such units. The publication also has list prices, data on ballast lead lengths, cross section dimensions, table on lead stripping and tinning, wiring diagrams, and electrical specifications for GE ballasts.

"Cats Eye" Literature. An extremely efficient optical system coupled with a unique "Cats Eye" slit produces a new photoelectric control which allows over 1,000 different uses. A folder, available from Mason Instrument Co., 27 Elm Ave., Mt. Vernon, N. Y., includes technical data, prices, and a partial list of its multitude of uses.

Plastic Coatings Booklet. "Fluidized Plastic Coatings for Corrosion Resistance" is the title of a special report, available in literature form, from the American Agile Corporation. The six-page brochure, a reprint of a feature article, covers such topics as the mechanism of fluidization, coatings available, cost factors, and applications. Copies may be obtained, without charge, from the American Agile Corporation, P. O. Box 168, Bedford, Ohio.

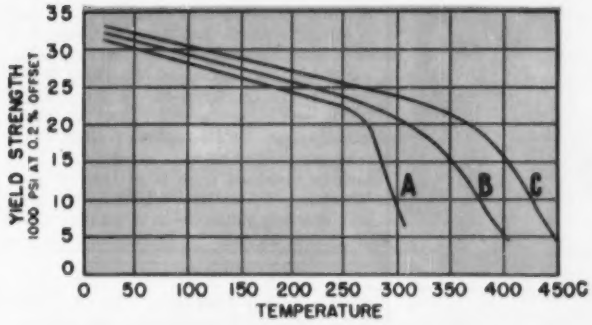
Polyvinyl Chloride Pipe Catalog. A 12-page two-color catalog available from Alpha Plastics Inc., 78 Okner Pkwy., Livingston, N. J., describes the firm's regular and high impact corrosion-resistant rigid polyvinyl chloride pipe. Included are tables of pipe sizes available, specific chemical applications, physical properties, temperature factors for various working pressures, support spacing, and thermal expansion.

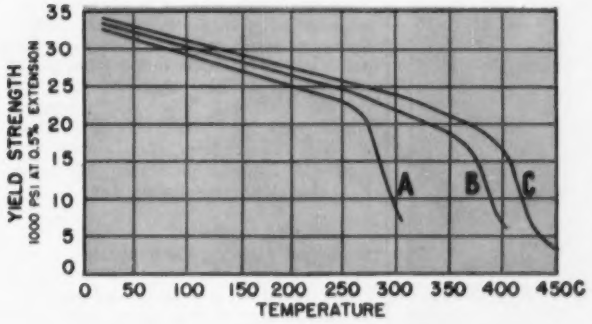
Armature Banding Tapes Bulletin. Bulletin *RE65-1* gives technical information on properties and application of RES-I-GLAS tapes. These nonwoven glass tapes are supplied with a semicured polyester binder, and thermoset to a hard rigid insulating laminate with design properties approximating steel. They have economically replaced steel and its insulation in diesel armatures and generators, mill motors, large generators, etc., with no failure record. Methods of balancing on the RES-I-GLAS band are discussed. Chicago Printed String Co., 225 Fifth Ave. New York 10, N. Y.

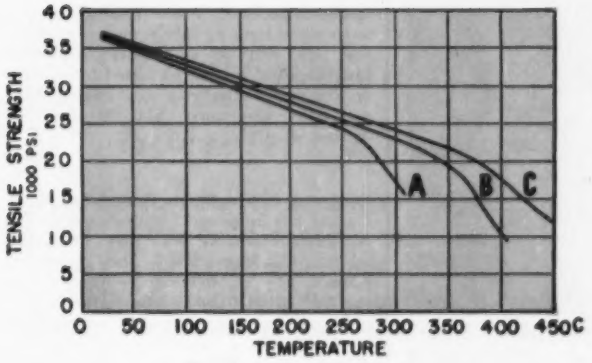
Radiant Heat Brochure. A comprehensive, free brochure, Bulletin *57-108*, describing the various applications of radiant heating equipment in metal processing has been published by Fostoria Pressed Steel Corp., Fostoria, Ohio. Eighteen typical applications are described in capsule case history form. Data on product heating ploblems, processing temperatures, time cycles, and oven design are included.

(Continued on page 92A)

How to give electrical conductors an improved margin of safety at elevated temperatures







A. Silver content normal
B. Silver 8.7 ounces per ton
C. Silver 28. ounces per ton

Copper strips cold rolled,	0.050 ins. gage
Time to heat, approximately	1¼ hours
Time of test at heat, approximately	¼ hour
Speed, testing machine head,	0.01 ins. per min.

American Brass Company Metallurgical Research Laboratory 1954

Tests show influence of silver on tensile properties of high-conductivity copper at elevated temperatures

Silver-bearing copper is used extensively in windings, collector rings, and commutators of motors and generators, in order to retain structural strength at elevated temperatures during assembly and operation.

There are now many other places where electrical conductors must stand up under temperatures well above those heretofore considered normal.

The amount of silver needed to meet a particular set of conditions, however, has until recently been difficult to determine. At the left are charts summarizing the results of tests made in The American Brass Company Metallurgical Research Laboratory, which can help serve as a more precise guide.

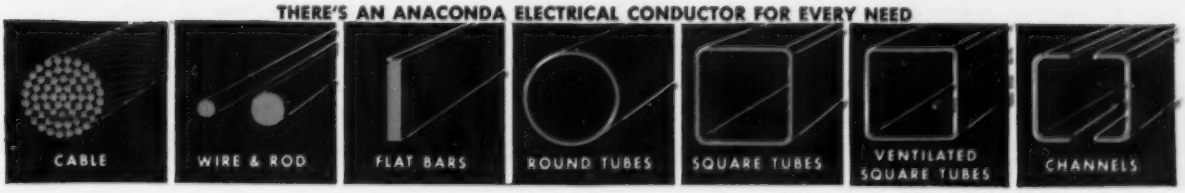
The curves for the yield strengths at 0.2 per cent offset and 0.5 per cent extension are significant to electrical engineers with problems involving the operation of conductors at elevated temperatures, for these values are indices of the limits of elastic behavior. The drop in absolute values of the tensile properties of all three coppers with rising temperature, however, should be noted and be allowed for in the selection of shape and size of conductors that are expected to run hot.

For more complete information on the effect of temperature on the mechanical and electrical properties of copper, send for a copy of Publication C-25, "Anaconda Copper for Electrical Conductors." This 62-page book also has a wealth of other general information, plus convenient new tables to help you in the selection of rigid bus conductors.

Technical Service. The assistance of Anaconda specialists in the selection of conductors to meet your special problems is available to you. For such assistance—or to get a copy of "Anaconda Copper for Electrical Conductors"—see your nearby Anaconda representative. Or write: The American Brass Company, Waterbury 20, Conn. 67101

ANACONDA®
COPPER CONDUCTORS
Made by The American Brass Company

THERE'S AN ANACONDA ELECTRICAL CONDUCTOR FOR EVERY NEED



WARNING -- Radar Trap!
One way to get a ticket that can't be fixed is to try a high-speed sneak attack past the line of "Texas Tower" radar sentinels now guarding our shores.
When an intruder approaches, his range, bearing, course and speed are instantly flashed to our Air Defense Command, along with voice and intercept command signals. This information, "multiplexed" by Lenkurt single-sideband carrier equipment, rides ashore on a microwave radio beam.
The carrier picked for this application is standard Lenkurt equipment — the same that is in daily use by America's telephone companies. Its adaptability, proved reliability and ease of maintenance have made it the logical first choice for many vital defense installations. It offers frequency economy, saves installation space, provides a maximum number of channels at a minimum unit cost.
To carry forward your own communications projects, join the growing list of commercial and government users who look to Lenkurt for leadership in telecommunications.
Lenkurt
ELECTRIC
San Carlos, Calif. • Mexico, D.F. • Vancouver, B.C.
Lenkurt products are distributed to public utilities by AUTOMATIC ELECTRIC

(Continued from page 90A)

Trade Literature

Decimal Equivalents Wall Chart. John Hassall, Inc., manufacturers of cold-headed products, offers a three-color wall chart of decimal equivalents, designed for easy reading. Decimals run down the center of each column. Guide lines join each decimal with its equivalent fraction. Thus, the user can quickly pick out the fraction he is seeking to convert and instantaneously find the decimal equivalent. Decimals are carried to four places. The chart may be obtained from John Hassall, Inc., Westbury, L. I. Also available for desk and drafting table use is a smaller chart of similar design.

Atomic Energy Literature. The "Guide to Atomic Energy Literature for the Civilian Application Program," *TID 4575*, has been released by the United States Atomic Energy Commission. This 74-page booklet describes the technical information publications and services offered by the Commission and tells how and where to obtain them. The Guide may be obtained without charge from the Commission's Technical Information Service Extension, P. O. Box 1001, Oak Ridge, Tenn.

Municipal Lighting Cable Catalog. A catalog covering a complete line of plastic cables designed specifically for the municipal lighting field is being made available by Ansonia Wire & Cable Company. Cables described in the catalog include series street lighting cables, parkway cables, and pole and bracket cables. Copies of this literature may be obtained by writing on company letterhead to Ansonia Wire & Cable Company, 111 Martin St., Ashton, R. I.

Computer Bibliography. Remington Rand Univac has announced a bibliography of computer literature for those interested in learning more about this absorbing subject. The publication, believed to be the first of its kind in the industry, has been prepared with emphasis on scientific and engineering use of computers. To obtain a copy, address a request to Remington Rand, Division of Sperry Rand Corporation, 315 Fourth Ave. New York 10, N. Y., and ask for booklet *EL 335*.

Control Circuit Transformer Bulletin. An improved line of control circuit transformers has been announced by Hevi-Duty Electric Company. These transformers, available in standard sizes from 0.05 to 5 kva, can handle up to 1000% inrush current with only a 5% voltage drop below rated capacity. This enables the user to specify a transformer size based on his sealed volt ampere requirement in all but a few isolated cases. Write Hevi-Duty Electric Company, 2040 West Wisconsin Ave., Milwaukee 1, Wis., for Bulletin *300* containing regulation curves, construction features, and dimensions of the Type *SZO* transformers.

ELECTRICAL ENGINEERS WANTED for development work on industrial instruments and automation. This involves electronically actuated industrial instruments, telemetering, electronic control and self-balancing recorders. Experienced Electrical Engineering graduates with working knowledge of servo mechanisms preferred. Liberal paid benefits including insurance, hospitalization, and pension. Send your reply to W. D. McCrea, Chief Engineer, The Bristol Company, Waterbury 20, Connecticut.

ELECTRICAL ENGINEERS

We have openings with good opportunity for advancement at our Pittsburg, California and Baton Rouge, Louisiana plants for electrical engineers. Applicant selected for California plant will receive initial orientation training in Baton Rouge, Louisiana. Minimum requirements BS degree with preferably 3 or more years experience in heavy chemical plant design and maintenance, some instrumentation experience desirable. Liberal benefit plans. Salary commensurate with ability and experience. Please submit resume of training and experience to:

R. S. Asbury
Ethyl Corporation
P. O. Box 341
Baton Rouge, Louisiana

The Engineering Societies Library

can be your library department. To your company a trained staff and a fully equipped library would be a valuable addition. Over 170,000 engineering texts, and files of every worthwhile periodical are available for further research to meet your specific needs—patents, design, research, construction, and management problems. Charges cover only the cost of the service, and represent but a fraction of the value you will receive.

The Engineering Societies Library
29 West 39th Street, New York 18, N. Y.
Mr. Ralph H. Phelps, Director

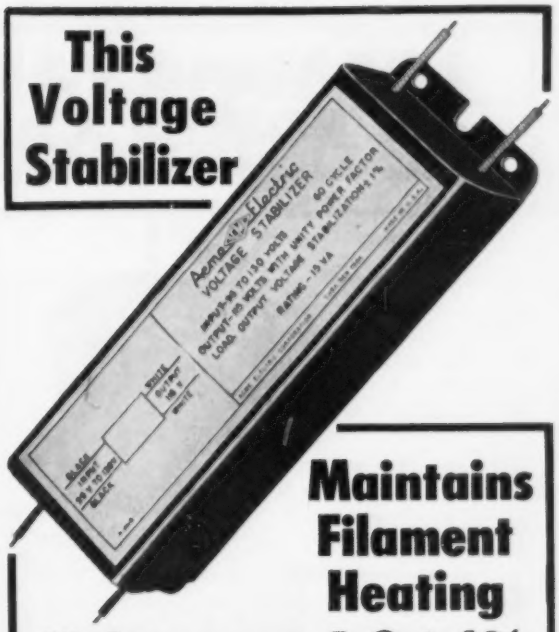
Please send me information pamphlet, on services available, and their cost.

Name .....

Street .....

City ..... State .....

This Voltage Stabilizer

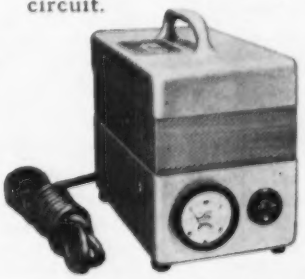


Maintains Filament Heating Voltage at 6.3 ± 1%

This is a standard, stock item, voltage stabilizer having an input voltage range of 95 to 130 volts and a nominal output of 6.3 volts stabilized at ±1%. Available from stock in 15, 25 and 50 VA capacities. No need to engineer special circuits or design specially tapped transformers to provide for filament heating at the required 6.3 volts. These stabilizers will do the job — better and usually less costly.

Output voltage stabilization is automatically obtained by a parallel combination of a fixed capacitance and a magnetic core inductance to provide the required variable capacitive current.

Voltage stabilization is further improved with a compensating winding to balance the output circuit.



Recovers Voltage Drop or Inductive Surge Within 1/30th second

The many design and performance features of Acme Electric stabilizers solve many problems caused by fluctuating voltage. Bulletin CVS-308, available on request gives full details and lists specifications of stabilizers up to 500 VA.

ACME ELECTRIC CORPORATION
2210 WATER ST. CUBA, NEW YORK

Acme ACME Electric
TRANSFORMERS

LOCATING FAULTS ON POWER CABLES

...under conditions which retard efforts by tracer methods

With submarine and buried cable, difficulty is often encountered in localizing and locating faults. Likewise in duct line construction, water-filled manholes, ice, snow and traffic can be serious deterrents in the use of tracer methods of fault location.

Biddle High Voltage Bridge

An unique instrument for locating faults on power cables.

Extremely compact, and designed for utmost safety and convenience. It embodies some features not found in any other Murray Loop type bridge.

Designed for Safe, Convenient Operation

Every detail of design has been conceived in the interest of maximum safety and convenience for the operator. The galvanometer and counter are observed through a clear plastic window in the top of the metal case. A special protective circuit prevents damage to the galvanometer in the event the fault resistance flashes over when a measurement is being made.

Unusually Fine Adjustment and Sensitivity

A high speed Veeder counter, geared to the moving contact assembly, ***indicates 10,000 divisions of the slide wire.*** The galvanometer is specially designed for ruggedness and sensitivity.

For Use With Biddle Cable Fault Locator Transmitters

The Biddle High Voltage Bridge was designed for use up to 25 kv to ground. The Model 3, 25 kv, Transmitter can be used as a power supply up to its maximum voltage. Likewise the Model 4, 15 kv, and Model 5, 5 kv, can be used up to their maximum voltage in the same manner as any ordinary d-c supply for Murray Loop bridges.

A Wide Range of Biddle Cable Fault Locating Equipment

We offer three models of our Impulse Cable Fault Locating Transmitters and D-C Proof Testers. Model 3 Transmitter, 25 kv, 1.65 muf, Model 4, 15 kv, 2.00 muf, and Model 5, 5 kv, 16.00 muf. If you have problems in locating faults in electric power cable, please write us.

Write for Bulletin 65-EE

B-714

JAMES G. BIDDLE CO.

- ELECTRICAL TESTING INSTRUMENTS
- SPEED MEASURING INSTRUMENTS
- LABORATORY & SCIENTIFIC EQUIPMENT

1316 ARCH STREET
PHILADELPHIA 7, PA.

RUGGED VERSATILE ELECTRONIC GALVO

20 uua or 0.2 uv per division sensitivity

Solve your bridge balance and low-level DC measurement problems with this sensitive, rugged, and versatile combination DC null detector, micro-micro-ammeter, microvoltmeter, and microvolt level DC amplifer.

Current sensitivity of the Model 204A is 20 times greater than high quality, mechanical current galvanometers. As a voltage galvanometer, its extremely high power sensitivity makes it superior to moving coil instruments.

Ideal for production testing, low level DC amplification to extend the range of recording instruments, or as a direct reading indicator for strain gage, thermocouple and other current or voltage measurements in industry or laboratory.

SPECIFICATIONS

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- All transistorized — Rugged — Insensitive to shock, microphonics, mounting position
- Withstands extreme overloads with no zero offset
- Floating input — 10,000 ohm fixed input resistance — No restrictions on source resistance.
- 10^{-14} full scale power sensitivity
- Use as stable DC amplifier with 1 volt at 1 milliamp output
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U.S.I.

Vol. II, No. 5

POLYETHYLENE PROCESSING TIPS

HOW CARBON BLACK QUALITY AFFECTS WEATHER RESISTANCE OF POLYETHYLENE

For cable jacketing and many other outdoor applications polyethylene offers substantial advantages over other materials. It is subject, however, to degradation from long exposure to sunlight unless the resin is properly protected.

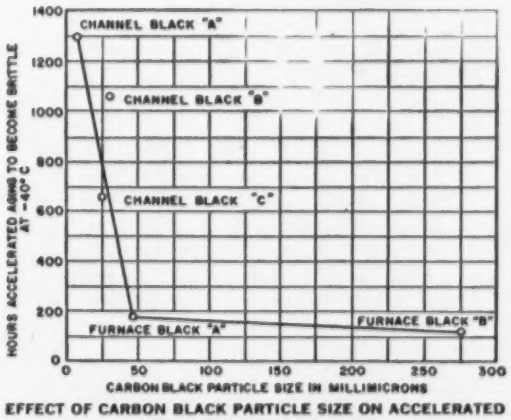
Actually, the aging of polyethylene is the result of a chemical reaction with atmospheric oxygen. Catalyzed by the ultraviolet rays in sunlight, this reaction proceeds more rapidly in outdoor use than is the case with indoor applications. The principal effects of aging are to increase brittleness at low temperature, and to decrease the resistance to stress cracking.

Carbon black dispersed throughout the polyethylene greatly retards this aging, or weathering. However, not all carbon blacks produce the same degree of weather resistance when dispersed in polyethylene. Moreover, the care with which the carbon black is dispersed in the polyethylene is vitally important.

The weather resistance of a polyethylene compound depends on: (1) type and particle size of carbon black; (2) percentage of carbon black in the compound; (3) the dispersion of the carbon black in the polyethylene.

Accelerated aging tests have been devised to approximate the action of years of outdoor exposure.

The graph below shows the great difference in number of hours required in these tests for a polyethylene to embrittle at −40°C when various carbon blacks having different particle sizes are used.



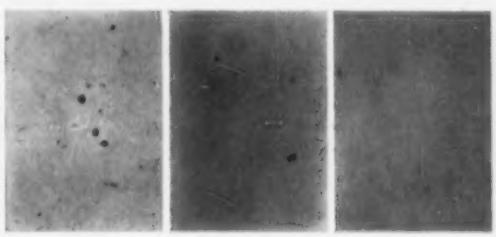
EFFECT OF CARBON BLACK PARTICLE SIZE ON ACCELERATED AGING OF POLYETHYLENE.

The two at right are "furnace blacks", and it will be noted that they are comparatively ineffective. The three at the left are "channel blacks", and obviously, they are many times more effective. This is due to their much smaller particle size – from about 10 to 25 millimicrons, against 50 to 275 millimicrons for furnace blacks.

Weather resistance also increases with the concentration of carbon-black – up to a point. Beyond this point the light screening effect is offset by a decline in other properties.

DEGREE OF DISPERSION IMPORTANT

Carbon black gives maximum protection only when it is thoroughly dispersed in the polyethylene. This presents a difficulty because the smaller the particles, the greater is their tendency to collect into clusters which, once formed, are hard to break up. Tests show that a good dispersion will withstand 15 to 20 times as much exposure to sunlight as a poor dispersion.



POOR FAIR GOOD

MICROPHOTOGRAPHS OF CARBON BLACK DISPERSIONS IN POLYETHYLENE.

The wire and cable grades of U.S.I.'s PETROTHENE polyethylene resins employ only the finest "channel black" carbon black. Concentration is set at a point which yields the optimum balance of light screening and other properties. Special processing equipment insures thorough dispersion. The result is black polyethylene that withstands long, severe outdoor exposure, yet affords the practical maximum of tensile and other properties.

If you fabricate or use black polyethylene, ask U.S.I. for complete technical data on PETROTHENE resins expressly formulated for weather resistance.

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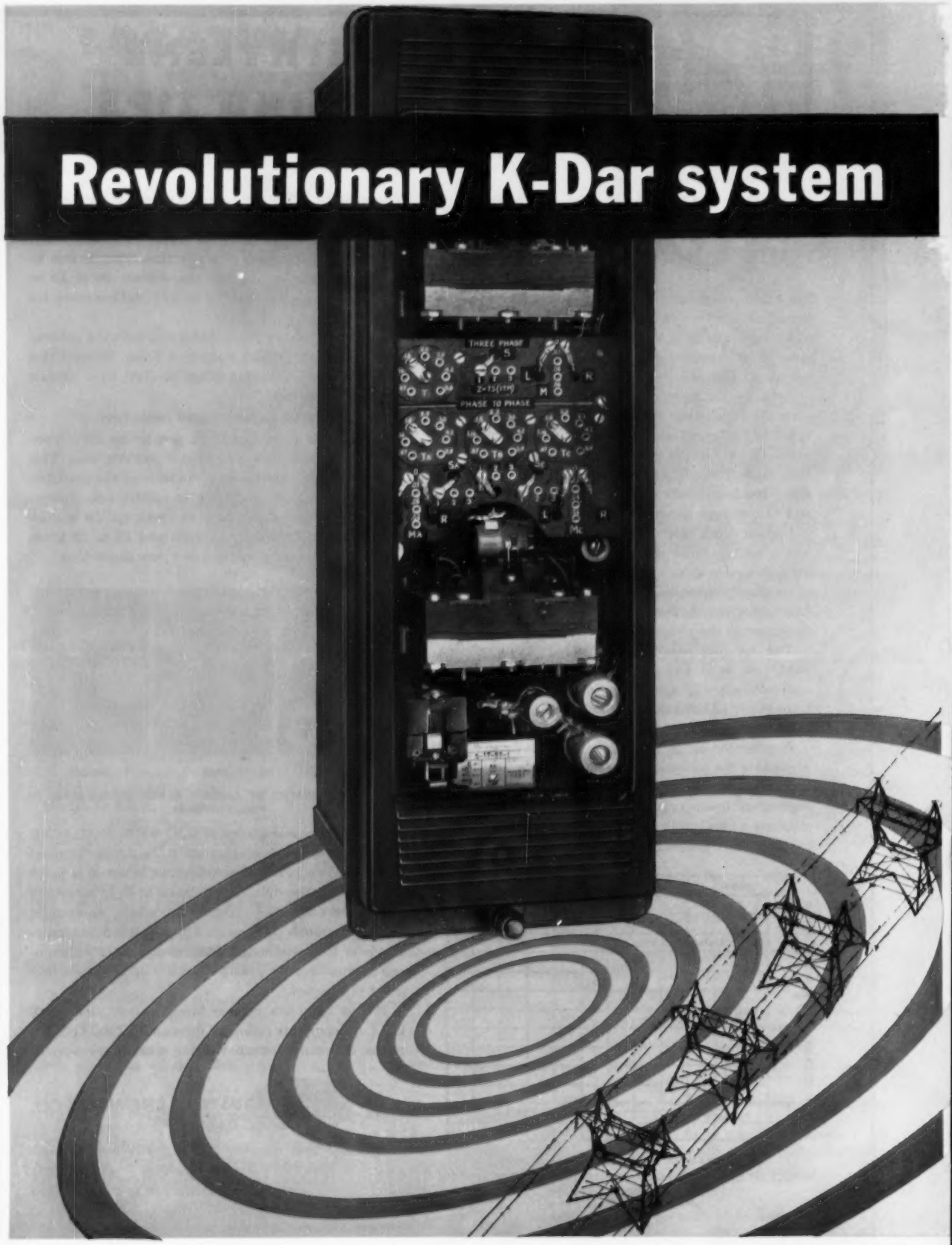
Revolutionary K-Dar system



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Transmission line phase fault protection using compensator distance relays

Relays making up the new K-Dar system provide high-speed protection of transmission lines from three-phase and phase-to-phase faults. K-Dar provides high-speed coverage of 90% of the line section with adjustable time-delay back-up of adjacent line sections . . . or provides simultaneous tripping of circuit breakers on a faulted section as a part of a carrier or micro-wave scheme.

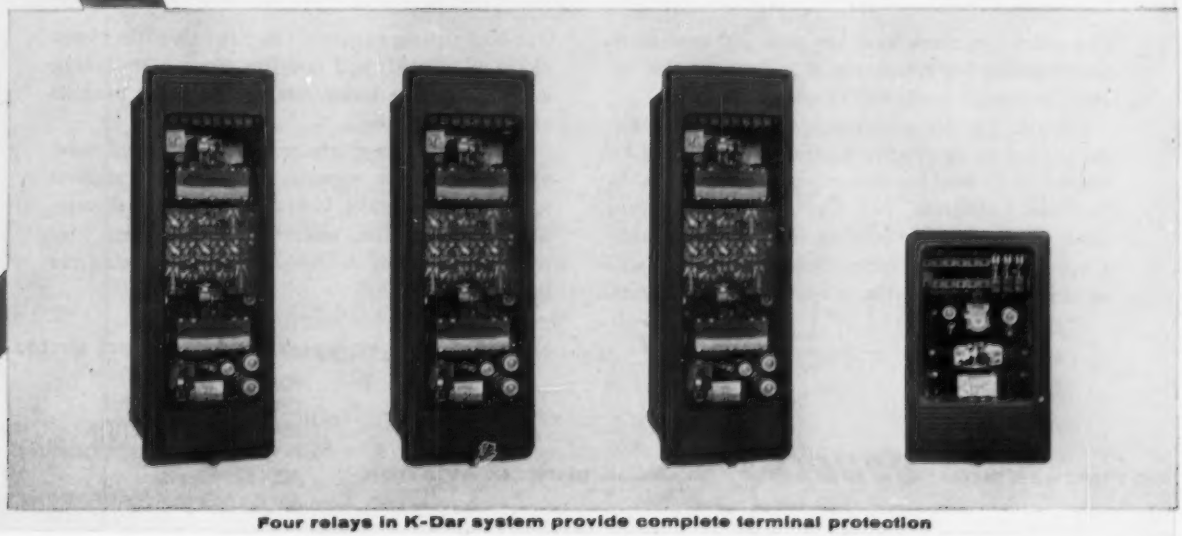
K-Dar is insensitive to transients . . . provides more accurate response to relay settings. Air gap compensators provide effective transient shunt. More reliable response permits relay setting to achieve greater line coverage.

K-Dar phase-to-phase relay unit operates independent of load current . . . Phase-to-phase settings can be made to reach further out on a line section because relay unit operates independent of load current or system-swing conditions.

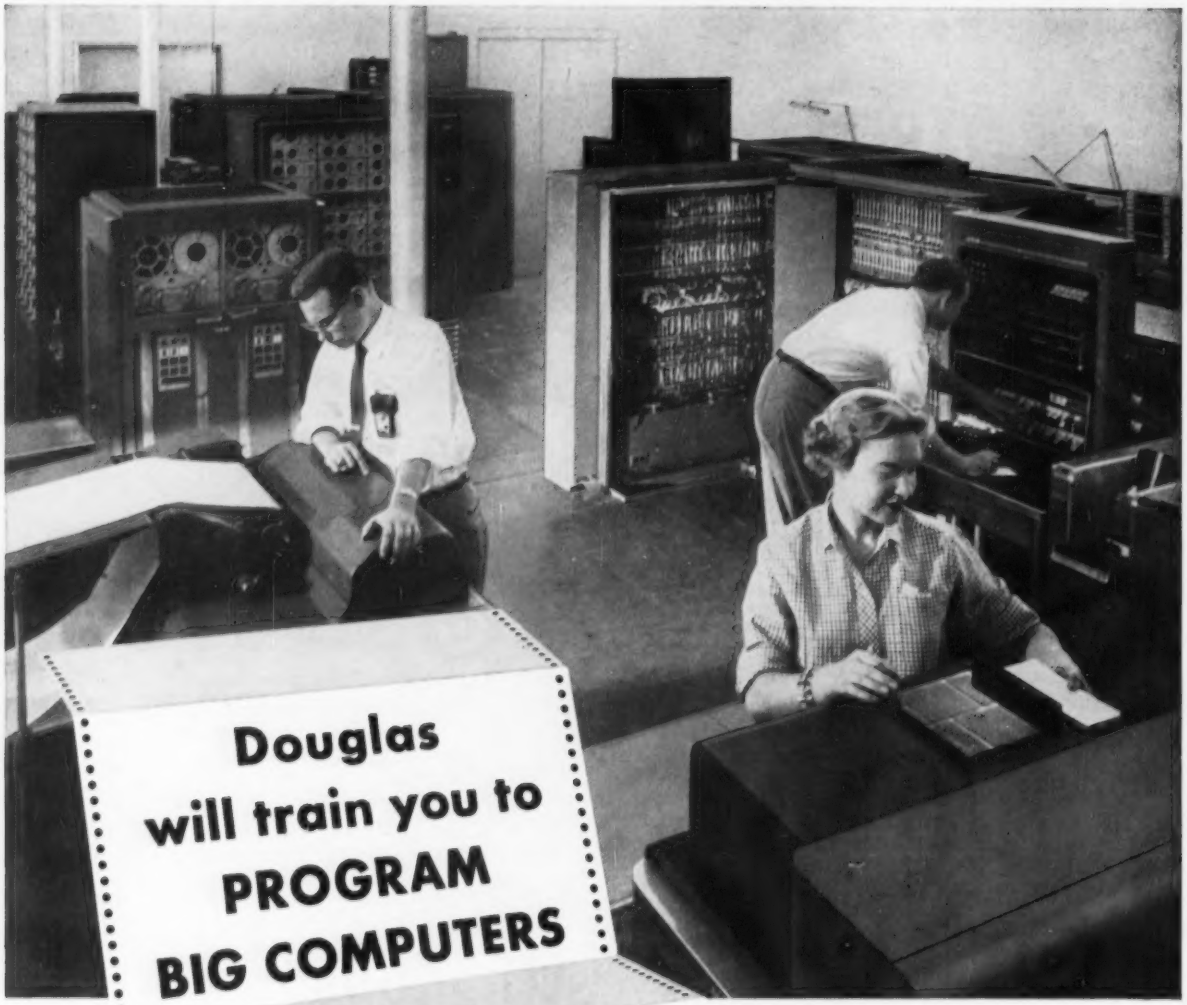
K-Dar features simplified design . . . Low maintenance with K-Dar . . . few moving parts. With few adjustments, relay setting is much easier . . . testing is reduced to a minimum.

For complete information about the new K-Dar system, call your Westinghouse salesman. Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. J-40500

YOU CAN BE SURE...IF IT'S Westinghouse



Four relays in K-Dar system provide complete terminal protection



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Our computing engineers are involved in every phase of aircraft and missiles work... including many long-range commercial and military projects of vital importance.

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frame of reference

The chart below is a simplified representation of 11 different staff member fields at Sandia Corporation. You might call it an occupational frame of reference, within which are located the many activities involved in our work—design and development of nuclear weapons for the Atomic Energy Commission. In each of the 11 fields, challenging positions are available for qualified engineers and scientists at all degree and experience levels.

	ENGINEERING	PHYSICS	MATHEMATICS
Applied Research			
Weapon Systems Engineering			
Component Development			
Electronic Development			
Handling Equipment Design			
Standards Engineering			
Quality Assurance and Surveillance			
Environmental Testing			
Field Testing			
Manufacturing Relations Engineering			
Military Liaison and Field Engineering			

There are many other things you'll want to know about Sandia Corporation. You'll be interested in our extremely liberal employee benefits. You'll want to know about the advantages of working and living in Albuquerque, famous for its healthful year-round climate and recreational attractions. You'll want information on schools, homes, and cultural facilities. And you'll want to know more about our work, and our background as a research and development laboratory. Our illustrated brochure answers these questions, and many others. For your copy, please write to Staff Employment Section 551A.

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PHYSICISTS MATHEMATICIANS
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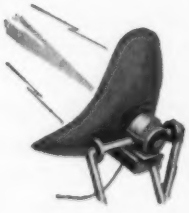
Several long range systems development programs have recently been awarded to Melpar, the execution of which require our engineers and scientists to pioneer into the no-man's-land of science. Of a highly advanced nature, these programs are vital to the Nation's defense and include *weapons systems evaluation* in a variety of fields and over 90 diversified projects in *electronic R & D.*

These long term assignments have created challenging openings which you are invited to consider. As a Melpar staff member you will become a member of a small project team charged with responsibility for *entire* projects, from initial conception to completion of prototype. Your advancement will be rapid, thanks to our policy of individual recognition, which promotes you on the basis of your performance, rather than age or tenure.



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Graduate Electrical Engineer capable of assuming responsibility in the solution of various technical problems related to communications systems in the electric utility field. Applicant preferably should have experience in layout, design, selection and application of communication and related equipment.

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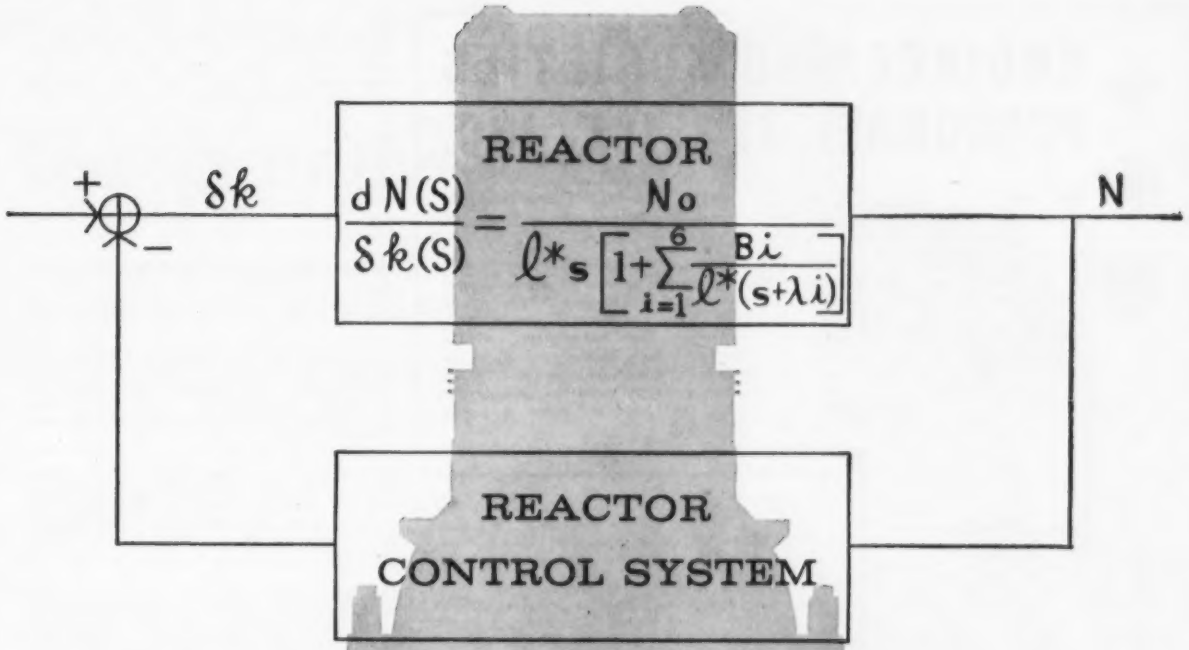
LIGHTNING REFERENCE BIBLIOGRAPHY
1936-1949

Prepared by the AIEE Lightning and Insulator Subcommittee, this bibliography, S-37, contains 754 separate references on lightning and related topics published from January 1, 1936, to December 31, 1949, in most of the better known English, French, and German journals on electrical engineering or physics.

For easy reference, there is a Subject Section, subdivided into 18 classifications, and an Author Section, which contains a list of about 550 authors. Price: $0.70 ($0.35 to AIEE members).

Available from the Order Department, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 33 West 39th Street, New York, N. Y.



Control Engineers Develop New Methods of Control and Analysis

Using standard servo-mechanism techniques, electrical engineers at Bettis Atomic Power Division design and develop control systems for nuclear power plants. For example, the above diagram illustrates the basic transfer function for a nuclear reactor showing the number of power producing neutrons as a function of control rod motion.

The work of the nuclear control engineer encompasses a wide range of engineering skills since he must acquire and apply a general knowledge of an entire nuclear power plant and a detailed knowledge of reactor dynamics. Because of the analytical nature of nuclear design, it is the control engineer who determines many of the basic plant parameters and operating limitations. The techniques he employs are very similar to conventional feed-back control and regulating system design practices as well as the utilization of techniques specifically developed for the atomic energy field.

Because of the rapid advancements in reactor design and technology, the control engineer is continually expected to develop new methods of control and analysis. His work is made even more important and interesting by such unique requirements as 100% fail-safe design, stringent component response times, and the use of all static components. It is, in fact, the responsibility of the nuclear control engineer to determine what part of the almost unlimited power available from a nuclear reactor can be safely harnessed and controlled for use by present commercial power machinery.

We welcome inquiries from electrical and control engineers interested in the excellent careers offered by one of the leaders in the new and growing nuclear power industry. Please send your résumés to: Mr. M. J. Downey, Bettis Atomic Power Division, Westinghouse Electric Corporation, Box 1468, Dept. A-185, Pittsburgh 30, Pa.

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Two weekly bulletins of engineering positions open, one covering positions on the Pacific Coast and the other covering Midwestern and East Coast positions, are published and each bulletin is available to members at a subscription rate of $3.50 per quarter or $12.00 per annum, and to nonmembers at $4.50 per quarter or $14.00 per annum.

Men Available

SALES MGR, B.S.E.E., age 38; 10 yrs sales mgr or sales engrg, power and distr eqpt to industrials and utils. Considerable exper in marketing, sales forecasting and sales promotion. Interested in progressive growing concern in elect eqpt or electronics. Location desired. Midwest or East. E-916-826-Chicago.

ELEC ENGR, B.S.E.E., age 41; exper in elec des for indus, educational and institutional proj. Also consulting work and supervision of constr. Location desired: West and Midwest. E-917.

GRAD ELEC & MECH ENGR, P. Engr; AIEE, EIC, CAN. citizen; P. G. courses nuclear engrg, bus org and indus mgmt; 8 yrs exper (mech and elec) for des, constr, in heating, ventilating, process and service piping, steam gen and distr; elec pwr gen and distr, controls lighting systems; chem, cement, paper industry. Presently employed supervisory pos; seeks challenging pos with mgmt scope. E-918.

Positions Available

SUPERVISORY SYSTEM ENGINEER, registered professional electrical engineer, thoroughly experienced in planning construction and operating practices of electrical transmission and distribution utilities. Previous experience in responsible positions is mandatory and demonstrated organizational ability is required. Public utility experience helpful. Salary open. Location, Alaska. W-5104.

SUPERVISOR, electrical section, engineering and construction department, graduate electrical, with extensive experience in industrial application of electric power; control and distribution systems; and the design, construction, installation, operation and testing of electric equipment. Supervisory experience highly desirable. Under direction, will supervise activities of section engaged in research on materials and equipment, predominantly electrical in nature. Salary, from $12,000 a year. Company pays placement fee. Location, eastern Pennsylvania. W-5139.

DIRECTOR OF SYSTEMS PLANNING, graduate electrical, 34-38, with five or more years' experience in staff and/or line positions in a company whose primary interests are in or related to an electrical field of endeavor, for a utility. Will be responsible for determining the nature and extent of facilities and equipment required for servicing customers in the utility's area; will plan future growth, oversee purchase and installation of facilities and equipment, etc. Salary, $15,000 a year with additional benefits. Location Midwest. W-5180.

CABLE SALES ENGINEER, 28-35, E.E., M.E., or Ch.E. degree or equivalent combination of training and experience, with at least three to five years' experience selling electrical multiconductor cables for a manufacturing organization. Similar or related internal experience in sales department of such a company acceptable. Should be executive calibre for potential sales management and administration responsibilities. Some traveling required throughout the U. S. Starting salary range, $8000-$9000 a year, plus travel expenses. Headquarters, New England. W-5192.

FACILITIES ENGINEER, B.S.E.E., with two years' electrical contracting or construction work, to perform electrical engineering and related work, including installation of production machinery and plant facilities equipment, etc. Salary, $6800-$8750 a year. Location, Midwest. W-5198(a).

ELECTRICAL INSTRUMENTATION ENGINEER, to 40, to do general plant electrical engineering and operate instrument shop. Will design moderately complicated instrument installations for chemical process plant. Salary, $7000-$9500 a year. Location, North Carolina. W-5206.

ELECTRICAL ENGINEERS. (a) Interference and Noise Engineer, electrical graduate, with background in RF field strength measurements, propagation characteristics from ULF through radar frequencies. All aspects of electronic interference and noise including evaluation, measurements and design improvements involving complete systems and/or unit equipment. Salary, $6000-$10,000 a year. (b) Systems Engineer, electrical graduate, with background in allocation and use of communications frequencies. Layout and design of specialized communication systems. Will need good theoretical background in use of above. Salary, $6000-$12,000 a year. (c) Research and Development Engineer, electrical graduate or equivalent experience, to work in R & D laboratory on theoretical and empirical development of circuits and devices of electronic, electro-mechanical or mechanical nature to fulfill specified requirements. Will initiate and supervise construction and testing of models and equipments to demonstrate practicality of developments. Will work under chief engineering supervisor as project head. Salary, $6000-$10,000 a year. Location, Washington, D. C. W-5220.

INSTRUMENT ENGINEERS. (a) Instrument Engineer, B.S.E.E., Ch.E., M.E., with three to four years' in selection, application and instrument system design for chemical process plants. Some operation desirable. Will work on designs, selection and application of instrumentation systems. Salary, $8100 a year. (b) Instrument Engineer, E.E., Ch.E., M.E., with two to four years' specifying and designing instrumentation systems for chemical process plants. Plant operation helpful. Will design and specify instrumentation. Salary, $7200 a year. (c) Instrument Engineer, E.E., Ch.E., M.E., with a minimum of four years' instrumentation design or two years' design and two years' operation. Specifying and layout instrumentation systems for chemical process plants. Will design and specify instrumentation. Salary, $8400 a year. Location, western Pennsylvania. W-5230

EXECUTIVE VICE PRESIDENT, Master's degree in Business Administration, electrical background, for manufacturing company in electrical communications field. Must have considerable experience in financial aspects of a large company. Salary, $20,000-$25,000 a year. Location, northern New Jersey. W-5259.

CHIEF ELECTRICAL ENGINEER to take charge of all electric power, lighting, distribution for large process industry. Salary, $12,000-$15,000 a year. Location, Cuba. F-5262(c).

SUPERINTENDENT OF MANUFACTURING, electrical, mechanical or industrial engineering graduate, with at least five years' supervisory production experience in TV and radio fields. Salary, $10,000-$12,000 a year. Location, New Jersey. W-5286.

ELECTRICAL INSTRUMENTATION ENGINEERS with a minimum of five years' experience in field of electrical instrumentation. Salaries open. Company pays placement fees. Applicants must be citizens of U. S. Location, New England. W-5287.

INSTRUMENTATION ENGINEER, B.S.E.E. or B.S.M.E., with five to ten years' experience in plant instrumentation and control work, preferably as applications engineer or sales engineer for control manufacturer. Will evaluate the feasibility of plant instrumentation development projects and furnish technical advice on instrumentation and control problems to production and engineering personnel. Salary, to $10,000 a year. Location, Pennsylvania. W-5294(a).

ENGINEERS. (a) Assistant Chief Engineer, under 40, electrical or mechanical graduate, with at least five years' supervisory design and development experience covering precision instruments, electro-mechanical devices and testing equipment. Salary, $12,000-$15,000 a year. Company pays placement fee. (b) Assistant Sales Manager, under 40, electrical or mechanical graduate, with sales and office administrative experience covering precision electro-mechanical equipment. Some traveling. Salary, $10,000-$12,000 a year. Company pays placement fee. Location, Connecticut. W-5304.

SALES ENGINEER, under 40, electrical graduate, with at least 15 years' sales and application experience in wire communication fields covering transistors, multi-vibrators, oscillators, transmitting and receiving systems. Salary, $12,000-$15,000 a year. Company pays placement fee. Location, East. W-5305.

ELECTRICAL ENGINEERS for development work on industrial instrumentation and automation, electrical graduate, with working knowledge of electronics and servo mechanisms. Several years' experience in project development work desirable preferably with industrial telemetering or electronic control. Salary open; company paid fringe benefits. Location, Connecticut. W-5307.

DESIGN ENGINEER, electrical graduate, with a minimum of three to five years' experience in design of electrical requirements for chemical plants, power and lighting controls, substations, communication systems, wiring, grounding for plant area process equipment requirements. Will prepare specifications and engineering design data; set design and select equipment with regard to safety, efficiency, reliability and economy. Salary, to $8400 a year. Company pays placement fees. Location, New York, N. Y. W-5319(a).

SENIOR ESTIMATOR, electrical graduate, or related training and background, with four to six years' experience in the design or estimating of distribution and control facilities, industrial lighting, power and electrical generation. Salary, to $8400 a year. Company pays placement fees. Location, New York, N. Y. W-5320(a).

(Continued on page 104A)

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How would you like to work in a place where there's a constant need for new products, new processes, new ideas? Where the technical job brings engineers in touch with such broad managerial functions as production, merchandising, installation, and many others? Where promotion from within is the policy . . . and over 8,000 management positions must be filled in the next ten years by newly promoted people?

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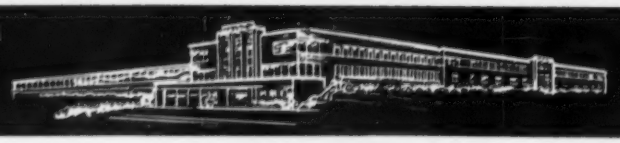
(Continued from page 102A)



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ELECTRICAL ENGINEERS, 2, for engineering department of electrical utility, graduates, with some experience. (a) One for Transmission and Distribution Section. (b) One for Planning Section. Salaries commensurate with technical and practical training and experience. Location, New England. W-5332.

SALES ENGINEER, 28-40, graduate electrical or mechanical, preferably married, with five or more years' selling experience, for company whose business is plastic extrusions for industry. Travel four to five days per week; home every week-end. Salary, to start, $9000 a year, plus expenses. Territory, New England, New York, Illinois, Michigan. Headquarters, Massachusetts. W-5337.

SALES ENGINEER, young, electrical graduate, with industrial experience in electrical insulation fields covering laminates, electric papers and sealing compounds. Considerable traveling New York State and New England. Salary, $6000-$8000 a year. Headquarters, New York, N. Y. W-5340.

RESEARCH AND DEVELOPMENT ENGINEERS; electrical or mechanical, M.S. or Ph.D. level, for microwave electronic tube field covering high vacuum techniques, electronic emission and beam formation, thermal and mechanical stability. Salaries open. Locations, New York Metropolitan area and Florida. W-5350.

STATION SUPERINTENDENT, graduate electrical or mechanical, for a new 44 MW steam electric generating station. Considerable experience required. Salary open. Location, Midwest. W-5351.

ENGINEERS. (a) Components Engineer, graduate electrical or mechanical, with previous experience in commercial electronic circuitry and assemblies, for liaison with sales and engineering groups and marketing analysis. Considerable traveling. Salary, to $12,000 a year. (b) Project Engineer, graduate electrical, with M.S. preferred, to coordinate, plan and direct all phases of engineering systems including engineering studies, experimental investigation, instrumentation and hardware development. Salary, to $14,000 a year. Location, Massachusetts. W-5352.

ASSISTANT SYSTEMS COMMUNICATIONS ENGINEER, B.S.E.E., to 40, with seven years' in design, specifications, construction, communications, with some management background. Know VHF radio, carrier, telephone, microwave. Will be second in command of department of 250; will supervise design, specifications procurement, construction of system communication facilities; develop policies, supervise subordinate engineers and supervisors, train for upward promotion in management. One third travel, no car required. Position is with a railroad. Salary, $7000-$8000 a year. Employer will pay placement fee. Location, Chicago, Ill. C-6360.

INDUSTRY ENGINEER, Major Electric-Steam Apparatus; E.E., M.E., to 40, recent graduate with ten years' experience with interest or knowledge of use of major equipage in particular industries (steel, cement, marine, power, manufacturing, etc.). Will provide technical information to local or regional offices relative to application of major electric or steam apparatus within a particular industry. Requires development of complete knowledge of needs of particular group of clients of sales offices in applying such apparatus. For major manufacturer. Continuing promotional program to develop professionally and managerially. Salary commensurate with experience plus fringe benefits. Location, headquarters eastern U.S. S-3048.

(Continued on page 106A)

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(Continued from page 104A)

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Flight path control
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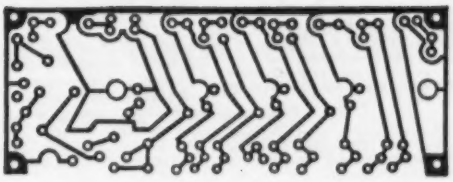

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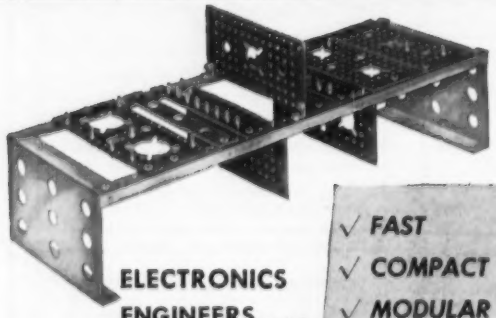

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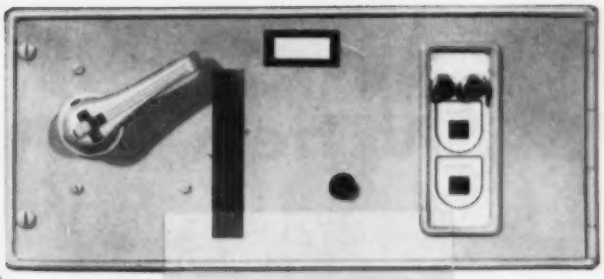

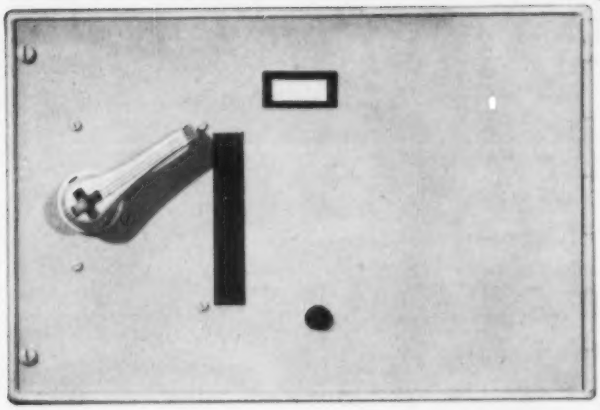

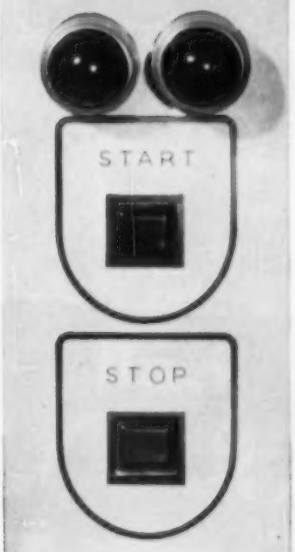

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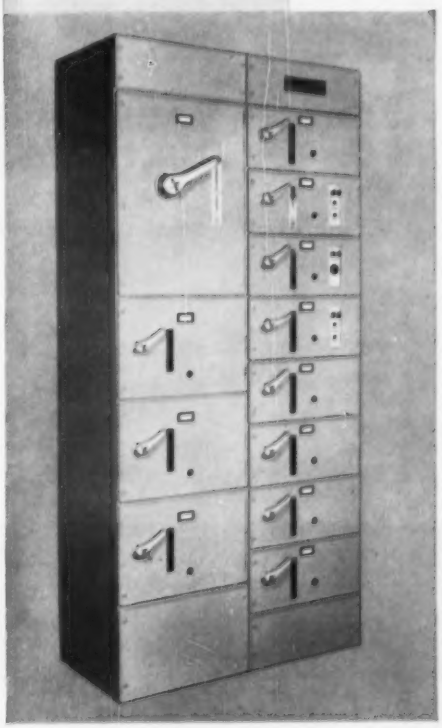

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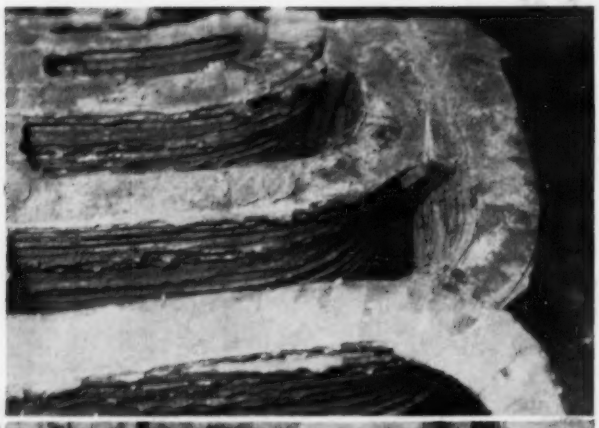

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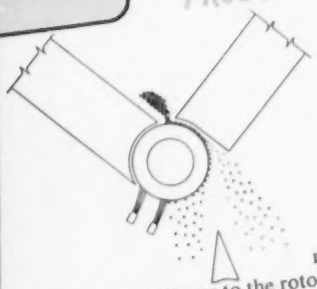
ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

New RCA Beam Power Tubes With

from the Variac® Case Book

PROBLEM:



To achieve accurate and reliable means for the control of the magnetic field and rotor speed of a mineral separator system.

The system: A heterogeneous mixture of minerals is hopper-fed onto a magnetized rotor. The magnetic material adheres to the rotor and is brushed off into a bin. The non-magnetic portion does not adhere and falls through the system into another bin.

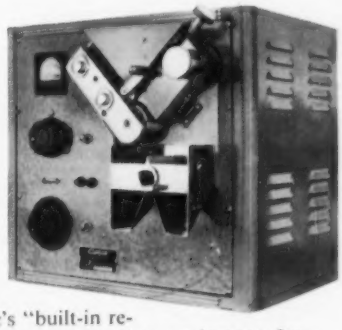
The controls for this system must be capable of regulating the magnetic field and/or the rotor speed so that materials of varying magnetic behavior are readily separated. The controls must operate efficiently and give clean separation at high feed rates even for materials with very low magnetic susceptibilities.

SOLUTION:

Two Type W5 Variac autotransformers are now used in the separator. One is used to control the magnetic flux, the other is used as the rotor speed control. Their smooth, stepless control and good voltage regulation assure positive adjustment. Rugged Variac construction (will withstand MIL-T-945A shock and vibration tests) insures long life and consistent, dependable service. A silver-plated brush track (Duratrak) gives the Variac additional "life insurance."

Variacs can be easily designed into equipment. They can be panel, behind-panel, wall, or table mounted. Square-cut bases of drawn aluminum alloy give Variacs added strength and mounting convenience.

RESULT:



Carpco Manufacturing, Inc. of Jacksonville, Florida, uses Variacs in their laboratory model magnetic separator. Designed for mineralogical assay and research work on small samples, it may also be used for production control and development. This separator is another example of how the Variac's "built-in reliability" aids manufacturers in designing equipment for long, trouble-free service.

Special Designs
Portable Models
350 to 1200 cycle Models
Cased Models
Ganged Models
Motor-Driven Models
Three-Phase Models

other Variac® models

are available with current ratings from 2.4 to 50 amperes — at prices ranging from $13.50 to $120. They may be ganged for additional capacity or polyphase operation.

Write for Complete Information

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Mass., U.S.A.

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8055 13th St. Silver Spring, Md. **WASHINGTON, D. C.** 1150 York Road, Abington, Pa. **PHILADELPHIA**
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In **CANADA**: 99 Floral Parkway **TORONTO 15**

Like all G-R Instruments, Variacs are covered by a 2-Year Warranty

s With New High-Efficiency Radiator

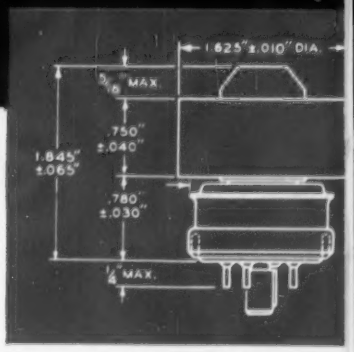
New RCA Beam Power Tubes With New High-Efficiency Radiator

RCA-7034/4X150A

With 2.5A Heater

RCA-7035/4X150D

With 6.3V 2.5A Heater



Higher Power Output... 370 Watts up to 150 Mc
Higher Plate Dissipation... 250 Watts up to 500 Mc

Unilaterally interchangeable with the 4X150A and 4X150D, these superior new RCA tubes feature a new specially designed, high-efficiency radiator which is hard soldered directly to the plate for better heat transfer. The 7034 and 7035 offer substantially higher power output capability at frequencies up to 150 Mc, and reliable operation with higher plate dissipation at frequencies up to 500 Mc.

Small and compact, the RCA-7034/4X150A and the RCA-7035/4X150D are useful as af power amplifiers and modulators, wide-band amplifiers in video applications, linear rf power amplifiers in single-sideband suppressed-carrier equipment, and class C amplifiers or oscillators.

Your RCA Field Representative at the RCA Office nearest you will be glad to give you sales information on these new types. For technical bulletin on RCA-7034/4X150A and RCA-7035/4X150D, write RCA Commercial Engineering, Section J 16 Q, Harrison, N. J.

TYPICAL CCS OPERATION
RF Power Amp. & Osc.—Class C Telegraphy

Up to 150 Mc.		
DC Plate Volts	1500	2000
DC Plate Ma.	250	250
Driving Power (watts)	1.5	2.5
Power Output (watts)	260	370
At 500 Mc.		
DC Plate Volts	600	1250
DC Plate Ma.	170	200
Driver Power Output (watts)	15	30
Useful Power Output (watts)	50	140

RCA Field Offices

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